



CONSERVATION ECONOMICS

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Conservation Economics
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Module 1
What is Economics?
Lecture 1
Making decisions

Namaste and welcome to this course on Conservation Economics. I am Doctor Ankur Awadhiya. I am an officer in the Indian Forest Service and your instructor for this course.

In this course, we shall try to understand how conservation and Economics are interlinked; how certain economic decisions - certain bad economic decisions - lead to issues of conservation; how they lead to environmental disasters and how we can make use of the principles of Economics to ensure that we also are able to meet our goals of conservation.

We shall also try to explore why conservation is important for the economic well being of a society. After all we require Economics - we require development - to provide certain amenities to our people. And when we do good conservation we can provide those amenities at a cheaper cost.

So, on the one hand Economics helps in good conservation. That is, good economic sense and good conservation at the same time. Good conservation helps in the development of the society which is also one of the objectives of Economics. We shall also try to explore how we can use the principles of Economics to provide funding for conservation.

These and several other issues will be discussed in this course. This course will be divided into several modules and each module will have three or four lectures. Each module will comprise those lectures that cover a thematic area in either Economics or conservation - or their interlinking.

The 1st module is: "What is Economics". In this module we will have three lectures. The first one is introduction to the course and making of decisions; the second lecture is making decisions part II and interactions, followed by interactions and working of the economy. We begin with the first lecture: "Introduction to the course and making decisions".

When we talk about Conservation Economics, the first question that comes into the mind is

"What is Conservation Economics?" That is, what is conservation? What is Economics? And how are both of these linked together?

The word conservation is derived from these word roots: con meaning together and servare which means to keep. So, essentially conservation means "to keep together." And what do you keep together? You keep together the natural environment because it is under threat. In one of the later lectures we shall explore what is causing this threat, why is our environment - and why are our wildlife - in great danger, and why we need to protect them.

We are not protecting these organisms because of our love for these organisms. We are not protecting tigers because we want to protect the tigers or because we are very much affectionate to tigers - because after all in most of the human history we have been killing tigers - because tiger is a ferocious animal. But, over time we came to this realisation that tiger also provides several benefits. Tiger protects the forest and forests provide us with several benefits such as clean air and clean water.

Forests ensure that our rivers and our streams have water throughout the year - they are perennial in nature. Forests ensure that whenever there is rainfall all the water does not just reach into the rivers causing floods and for the rest of the season the rivers get dried up. Forests have a role.

Where there are forests there will also be herbivores - animals such as deer, animals such as sambar. Now, if these animals are there in the forest - these herbivores are there in the forest - and there is no carnivore that is predating over them, that is eating them as prey - in such a scenario the number of herbivores would go up like crazy, they would eat up all the young plants.

Now, for a forest to continue it requires that the seeds of the trees get germinated and the young plants that come up are able to survive. But if herbivores eat up all the young plants then we will have a stage at which the forest will only have old trees.

And, in such a scenario, if there is any catastrophe - if there is a forest fire, if there is a disease, then this whole forest will be gone. Or even if we do not have a disease - in certain point of time those trees that are old will die off and in the absence of young regeneration the forest will not be able to come back. So, we need to keep a check on the population of herbivores.

How do we keep the population of herbivores in check? Well, we can do two things - one, we can go into the forest and we can start killing up these herbivores, but when we do that in a short time we will come to the realisation that these herbivores are also playing a role in the maintenance of the forest - because the seeds of a large number of plants require these herbivores. When these herbivores eat up the fruits, the seeds - when they pass through the alimentary canal or the gut - become more suited for germination.

So, if you just take the seed and put it into the ground it will probably not germinate, but once it has passed through the alimentary canal of these herbivores - the seed will germinate. A number of plants also use these herbivores as transporters of their seeds.

Because what happens is: if you have a tree in a location - and if all the seeds or all the fruits of this tree fall down here itself, the young plants that will come up - they will be coming up in the shade of the mother tree. And, when we say the shade of the mother tree it means that these young plants will not have sufficient sunlight and so, these plants will not be able to grow.

So, the seeds require a mechanism to transport these fruits and these seeds to other locations and one such mode of transportation is the herbivores. When the herbivores eat up a fruit - and the herbivores are moving - the plants are stationary, but the herbivores are able to move. When they move then this fruit or the seed that is within their stomach also moves with them.

And, when these herbivores go to another area and they defecate, then the seeds are able to germinate in those areas. What happens is that by using herbivores the trees ensure that the plants are coming up away from the shady areas, in those areas where they can actually grow into new plants, into new trees. So, the herbivores also have a role in the ecosystem.

Now, the question is: We need to maintain these herbivores in a quantity that is neither too high - because if it is too high then all the plants get eaten - nor it is too low - because if it is too low then also the forests are gone and when the forests are gone all the benefits that we get from the forest they are also gone. How do we maintain that? Well, we could do another thing.

We could keep a track of all the herbivores, their populations, which herbivores are where - keep a track of things and start to kill certain herbivores to maintain the numbers.

But, once we start to do that we will come into another problem because when a tiger eats up a deer, then it is eating that deer that is either diseased or it is too old because of which this deer is not able to run fast. But, when humans get into the field, once humans are permitted to get into the forest with guns to kill deers to keep the population in check, how will they know whether a deer is in the prime of the health or it is a diseased deer? In a number of cases what has been found is that whenever people were doing hunting, they were killing off the best animals - because the humans also have a desire to use things such as the hides of the animals.

So, if you permit humans to kill these herbivores to keep their population in check what will happen is that they will kill off those animals that are the best animals and in a short while you will observe that the herbivore population is now only having diseased animals. And, so, in the long run the herbivore population again will be gone which will again have negative consequences.

Now, at the same time when we use humans to keep these populations in check just think about how much amount of computations will need to be made. You will have to keep a record of each and every animal, find out which animal is healthy, which animal is not healthy and then track that animal and kill that animal, so that the population is kept in check. But, you are also killing off only those animals that are either diseased or weak, so that the herbivore population remains a healthy population.

Now, just think of how much amount of effort would be required! The other option is: just have a predator in the jungle - just have the tigers! Tigers will do everything for you. What can be better than that? When we talk about conservation, when we say that we are keeping things together, we are doing preservation - protection and restoration of natural environment and wildlife. This is not because we are very fond of tigers but this is because we need the tigers.

We need these forests, we need these wildlife because they serve purpose for ourselves. Whenever you find a new disease people will start to look for cures. Now, a large number of cures are found from different plants. You must have heard of the name of quinine. Quinine is a medicine that is used to treat malaria and quinine comes from the bark of the cinchona tree.

Now, of course, the cinchona tree is not infested with mosquitoes - the cinchona tree is not protecting itself. But, what is happening is that the cinchona tree produces the secondary metabolites to protect itself from the predators and the predators of the cinchona tree are things like insects or herbivores. When you have this quinine in the bark, then the quinine is very bitter in taste and so, the herbivores avoid it. The insects also avoid getting into this plant.

But when humans discovered that there is this chemical quinine, we extracted those chemicals and that was used as an antimalarial and once you have found this chemical you can always synthesise it in an industrial reactor. But, first of all you should know that there is such a chemical that can help you. Now, to have such chemicals it is important to have the cinchona trees. Now, whenever we get a new disease we will again start to look for the chemicals that can be used to treat this disease and where we will they get these chemicals from? From the plants! And where do we have these plants? We find them in the forest! Because when we talk about an agricultural field, then we are talking about a monoculture. People only grow paddy, people only grow wheat or there are maximum two or three crops that are grown, but when when you are looking for new chemicals you have to look for biodiversity. So, when we say that we are protecting a forest we are not protecting the forest because we love the forest. We are protecting the forest because we need the forest - because forests provide us with certain benefits.

And, when we talk about Economics, Economics is also concerned about providing benefits to people. When we say that we want an economic development, it means that you want to have more of more things. That is, we should have more electricity, we should have more vehicles, we

should have better houses - that is economic development.

But what is the premise of economic development? It is to provide comfort to people. And biodiversity is also doing the same thing! Because if you have good houses, you have good vehicles, you have sufficient electricity, but everybody is diseased - will you say that the society is a very happy society? Or when you have a medicine that treats these diseases and people are healthy? What do you prefer?

Obviously, people will prefer to have a healthy population and to have that healthy population we need clean air, we need clean water, we need biodiversity which will give us medicines, we need food, we need fibres, we need water, we need a lot number of things. And for that, we need to do conservation, that is the preservation, protection and restoration of the natural environment and wildlife.

Then what is Economics? The word Economics comes from these word roots - oikos means house and nemein is to manage. So, Economics is the study of how to manage a household and some of the best economists are the ones who are managing our households because in a household you need to make several decisions: What sort of food needs to be prepared, so that everybody is happy? You cannot have a just one thing throughout your life. So, every day you would need something different. Now, to we make that something different, you will require ,say, food grains, you will require salt, you will require oil.

Now, whenever we are having these things and we are making a food item - let us say that we are preparing dosa. Now, when we are preparing dosa we will require oil. So, the oil needs to be had in a quantity that we should always have oil available to make dosas, but we cannot also store a very large amount of oil otherwise it will get rancid. Things get spoiled if they are stored for a very long period of time. So, we need to make a number of decisions - what to buy, when to buy, in how much quantity to buy, what to produce in on different days and how to decide for whom to produce. Do you want to produce the food taking into account the children in the house or taking into account the adults in the house or taking into account the old people in the house - because they will have different requirements.

They will be happy with different things. The children might like to eat sweet items more, but the adults might want to go for more healthy food items. They want to have salads more. Now, the thing is you need to make these decisions: what to produce, for whom to produce, when to produce, how much to produce and these are the same decisions that we need to make even at the level of the society.

Economics is derived from the word roots house and manage. It is the science of managing the household or the science of managing the society, the study of how society manages its scarce resources. So, as a society as well we have these questions: what to produce, for whom to

produce, how much to produce, when to produce, and we take the same insights from the management of household to the management of the society because the principles remain the same. So, this is Economics.

Economics is a science of making decisions and these decisions are necessary because there is a scarcity of resources. Now, how are conservation and Economics related to each other? In conservation we are saying that we need to keep things together - we need to protect the natural environment. And in the case of Economics we are saying how does the society manage its scarce resources. How are they connected to each other?

Well, there is a very great intricate relationship between both of these because certain economic decisions have ruined the environment - things like pollution due to industrial revolution. Now, when we talk about what to produce in a household - what food items to produce, we are making this decision to ensure that everybody gets a sufficient nutritious food and everybody gets the food of their liking which means that we want to make everybody happy. In Economics terms, we say that we need to maximise the happiness - or the surplus.

When we are trying to do that it is possible that in the short run we make certain decisions that are not the most optimum decisions. So, for instance, a factory is being set up in your neighbourhood and you think that ok this factory is going to provide us with jobs. But once this factory has been set up you find out that it gives out so much amount of noise and so much amount of fumes and smoke and noxious gases that it is now difficult for you to even breathe in the area. Now, when this factory was being built you were in support of this factory, but once it has started its operations you think that oh we were much better before this factory was built in this area, at least we had clean air to breathe, at least we were not having this noise.

Now, the thing is that factory in itself is not a bad thing, but when we talk about implementation of things we need to know why the factory owners chose not to install noise controlling devices or not to install the smoke controlling devices. These are because of things that are known as externalities. We will have a lecture devoted to externalities which helps us understand why people make these decisions that harm everybody.

In short what is happening is that the factory owner thinks that ok, if I install this device there is a cost that is involved, but if I do not install this device then I am saving money. The consequences are being faced or are being suffered by people in the society but, I am not suffering the consequences because I live far away and there the air is good. We will observe that a large number of countries these days are taking this choice to move their polluting industries to certain other countries.

So, in that case they are saying ok let us have the profits, but we should not have this pollution in our country because we want clean air. Now, Economics also gives us options to ensure that

people install these devices and we will look at things like the Coase theorem that can help us ensure that these pollution controlling devices get installed.

But what happens is that certain economic decisions - especially bad economic decisions - ruin the environment and so, the environment needs to be protected. In the case of conservation we were talking about the protection of the natural environment. If the natural environment is getting degraded because of certain economic decisions then conservation is required. So, both of these fields are related in this way.

Another thing is some economic decisions have led to a total collapse of the ecosystems - extinction of species such as over harvesting of whales or extinction of dodo. Now, dodo was a bird that was extensively hunted for meat. It was a flightless bird. It could not fly away to protect itself with the consequence that people hunted it to such an extent that now not a single dodo remains on this planet.

This is not just the story of dodo. We are doing this every day to a large number of species in the name of economic development. In one of the lectures we shall explore what is the level of this loss that is happening. Now, remember that these species are required for the well functioning of the natural ecosystems. The dodo also had a certain role, it was required for the germination of certain species of trees and with the dodo gone those trees are also gone. There are a large number of inter linkages.

Now, probably, when we talk about a new disease there was certain chemical in that tree that could have been useful in treating the disease, but once that tree is gone you do not have any access to that chemical. So, certain economic decisions have led to a total collapse of ecosystems and for that we again need to go back to conservation. How do we bring the things back?

So, some economic decisions have led to a situation that is calling for conservation. At the same time conservation requires funding and resources. When we talk about Economics we are asking the question: how does the economy or how does the society manage its scarce resources? We have money, but we have also different things that require money. We can use the money to construct a school, we can use the money to construct a hospital or we can use the money to conserve the forest. How do we ensure that there is some amount of money that is made available for the conservation of forests? For the conservation of biodiversity?

Remember here again that we are not trying to conserve biodiversity because we love the forest - because man is a selfish being and we want to conserve the forest only because it provides us with certain benefits that we cannot have otherwise. But, these resources can come only when they are allotted for in the present and the future economic decisions.

And, so, if the conservationists and if the economists are not on talking terms then we will have a

situation where both will be at logger heads - whereas actually, both are working for the same goal - both are working to maximise the surplus of the society. The only difference is that a person who does not know about conservation will have only a limited set of choices.

A person who does not know the benefits of forest would say that ok we can construct a dam but, he would not know that we could have done the same thing for a much cheaper cost. Another example is that when we talk about tidal surges or when we talk about tsunamis then these days it is a fashion that we should construct a wall along our shores and these walls will protect against the sea water that is rushing in during the tsunami. Well, good enough, but then if you have mangrove forest in place of the wall you will also have the same benefit and mangrove forest will also protect your biodiversity. They will also clean up the water; they will also clean up the air. Your wall is not going to do that. So, you are getting more benefits for a lesser cost, but then to make this decision the economist needs to know what are the benefits of conservation and so, here is a relationship between Economics and conservation.

Economic decisions have the power to promote conservation - when we talk about renewable energy, when we talk about green technology, etc. Why are we shifting towards renewable energy? Well, we are shifting towards renewable energy because there is a shortage of petroleum. The price of petroleum increases and when that happens the cost of energy also increases. At the same time whenever we are talking about the use of petroleum or coal to generate electricity, it generates huge amounts of pollution. When we talk about renewable energy we can have the same energy there is no difference between the electricity that is generated by renewable sources such as solar energy or wind energy and the electricity that is generated out of a thermal power plant - the electricity is the same!

But we can have that electricity for a cheaper cost and with less amount of pollution and a number of economic decisions have been promoting conservation. So, when the government says that we should shift from incandescent bulbs to LED bulbs, the government is making this choice - or is promoting this choice - so that the amount of energy consumption reduces because we only have a limited capacity to produce electricity, but then once we do that we are also aiding conservation.

So, the thing is can we correlate both of these together so that we can have the best of both worlds? Conservation aids Economics, so that you are able to get the maximum utility at a cheaper cost and at the same time Economics aids conservation so that you are able to protect and preserve the environment. This is the relationship between conservation and Economics and this is what we are going to explore in this course.

This course will have several modules. The first one is: What is Economics. With these three lectures: Introduction, making decisions, interactions and the working of the economy. The second module will explore about conservation. Conservation in the anthropocene; anthropos is human beings and cene is a time period.

We call the current era as anthropocene because in today's era the impact of human beings on everything - on climate, on geology, on biodiversity - is much greater than any other factor. We say that that today is the man's age, but the thing is in this anthropocene - that is the age of human beings - what is the need for conservation? Do we need it or not? We will also explore human population growth and food requirements because our populations have been increasing with time and more people means that we require more resources. And, remember that Economics is the science of making decisions - about how to use the scarce resources for maximum benefit.

Now, if the number of people goes up the per capita availability of resources goes down. What can we do to ensure that the people still have access to resources? How does population grow? How do we provide it with food and other requirements? And, when we are meeting these requirements are we meeting that sustainably or unsustainably? This comes to sustainable and unsustainable development. The difference is that if you have a resource you can use it to get benefits for a very long period of time or you can use it to get benefit for a short period of time. You would have heard of the story of the hen or the goose that was laying golden eggs. Now, the farmer that was having this goose that was laying golden eggs was getting one egg every day and it was a golden egg. The farmer could have had these eggs for a very long period of time, say, for many months or say, many years. When we talk about having those eggs for a very long period of time we are talking about sustainable use. But, what the farmer did was that the farmer got very greedy and said that ok, there are eggs inside this hen or this goose so let us kill this goose and take out all the eggs. Once that was done the goose is dead and so, now, there are no more golden eggs. That is unsustainable development.

When we talk about sustainability we are asking the question that ok there is this lake; this lake has fishes. How many fishes do I take out every day, so that the fish population is also able to maintain itself and I am able to get this many number of fishes for a very long period of time?

Sustainable development is development that lasts not just for a short period of time, but for a very long period of time typically for many generations. So, we are using resources in such a manner that we are able to meet our present needs while also ensuring that our future generations are also in a position to meet their needs. We do not over exploit the resources so that nothing is left for our children and our grandchildren - that is sustainable development.

In the third module, we will talk about the modern impacts that necessitate conservation. We will talk about things like climate change, plastics, oil spills and mining. These are certain impacts because of which conservation has become an urgency. We are generating so much amount of plastics that a large quantity is being dumped into the environment and it is leading to negative consequences. We are dumping so much amount of carbon dioxide that there is a huge amount of global warming. We are observing changes in the climate today, we are observing the sea levels rise right before our eyes and if we do not do anything to solve this problem, then probably it

will be too late. So, these are the certain impacts of human beings that are now necessitating conservation as an urgency.

In module 4, we will look at threats to wildlife. We will look at push and pull factors. If you talk about any organism it has certain requirements - requirements of food, requirements of an amiable climate, the maximum-minimum temperatures, requirements of water, requirements of space. Those areas that provide these requirements give a pull factor to these organisms - that is, the organisms can live in those areas. The areas that do not provide these necessities of life give a push factor to the organisms - that is, the organisms will no longer live in this area.

Now, if you have a situation in which the organism is finding that everywhere it is getting pushed and there is nowhere to live, then the species will move towards extinction. So, push and pull factors are those factors that help us understand the threats to species and understanding these threats is important when we want to conserve these species.

And here we will also talk about ecotoxicology and developmental hazards: what are the hazards of development, what are the kinds of toxins that we are releasing in the name of development, what are the negative impacts of those toxins, and what kinds of influences do they have on the working of the ecosystems. That is ecotoxicology.

In the fifth module we will ask the question: "Can Economics help and how (can Economics help)." Because a large number of these decisions are occurring because of bad economic decisions we need to understand how economic decisions are made in the first place because once you understand Economics only then will you be able to use Economics to conserve the wildlife, to conserve the natural resources. In this module we will look at the need to understand controls. We need to understand how both of these are related and we will learn about thinking as an economist - what is the thought process that goes on in an economist's mind?

We will further look at interdependence and gains from trade. In a large number of cases these economic decisions are being made to maximise profits and these profits are coming from trade. So, trade is an essential thing that we need to understand the working of the economy. This trade happens in the markets - markets are places where Economics works.

We will explore markets in the 6th module. We will look at what is demand, what is supply, what is elasticity and how can government policies influence the market outcomes.

Suppose the market says that no, we need these materials in such a large quantity that even unsustainable development is what we will go for. Then government has the responsibility and government has the power to ensure that these market outcomes are modulated, they are tempered down so that we also ensure that everybody is able to get their due share.

What we are asking is if there is a certain group of people who says that no we are going to go for gas guzzling vehicles; we want the largest size SUVs even if we have to travel alone - in that case the pollution that gets released will cause an impact on all the people not just the person who is driving the SUV. Can the government do something to desist people from using these SUVs or desist people from using those vehicles that are not fuel efficient? This brings us to the role of government policy.

In the 7th module we will look at markets, welfare and conservation. Markets are important because they enhance the welfare of the society; they enhance the surplus of the society. We will understand what is surplus, how the surplus is measured and why do we want to go for economic development at all. And, we will look at market efficiency, cost of taxation and international trade in this context.

In module 8, we will look at public sector and conservation. In this case we will talk about things like externalities. Externalities are the impacts of one person's actions on the welfare of the bystanders. Remember that we are going for economic development to increase welfare, to increase surplus, but if there are certain actions that reduce the welfare, then those actions are known as externalities.

E.g., if one person is playing a very loud music and he is enjoying the party, but the people in the surrounding are not able to sleep, then that is an externality. How can we solve this problem of externalities? How can we come up with a solution that the person is able to hear music, but others are also not disturbed? We will look at public goods and common resources that mostly the government supplies for and the design of the tax system which pays for the public sector and conservation.

In the 9th module, we shall look at industrial organisation and conservation. A large number of bad economic decisions are to maximise the profit; they are because of cost cutting measures. Now, why do industries go for cost cutting? To understand that we need to understand how these industries make this decision of how much to produce and at what price to produce. So, in the 9th module we will look at the cost of production.

Competition and monopoly: You can have a competitive market or you can have a monopolistic market where there is only one seller. We need to understand how a seller in a competitive market makes decisions and how a seller in a monopolist market makes decisions because these are the decisions that have a ramification for conservation.

In the 10th module we will look at Labour Market Economics and conservation. In this case we will ask what are the markets for the factors of production that is what is the market for labour. The people who do work are also working in a certain market. They are providing their labour; they sell a sellable product and they are getting wages in return. That is the price that they are

getting.

What determines how much will be the wages? What determines how many people get employed? This is important because in a number of cases we have observed that when people are very poor, when their productivity is very less; then to feed the people they will want to extend their fields into the forest. They will want to cut down forests to expand their agricultural fields. This is because their productivity is less.

So, if we want to do conservation we would want to ensure that people are not poor: Everybody gets sufficient resources, so that they do not have to put a very great amount of pressure on the environment. This is what we will explore in module 10 - markets for factors of production, earnings and discrimination, and income inequality and poverty.

From modules 1 to 10 we will be working on several theoretical aspects that is we will make certain assumptions: that people are rational beings, that people want to maximise their surplus or their benefit. But in a number of cases these assumptions do not hold true because if you go to the market it is not that at all times you are trying to think that what will give me the maximum benefit.

It is also possible that your parents said that you should go and buy this particular brand of soap and you go and buy that particular brand of soap without giving a thought whether there are other soap brands that are probably better or cheaper. Now, when we have this sort of a situation, we are talking about the things like Behavioural Economics, the role of Psychology in Economics.

In the 11th module we will look at such practical issues as consumer choice. If there is an option to have two vehicles and one vehicle is say very fuel efficient - it does not give out lot of pollution, but it is a bit expensive and there is another vehicle that is a gas guzzler, but it is cheaper. How does a consumer decide which vehicle to buy? What are the psychological insights in that? When there are two parties and they do not have sufficient information how do they process? How do they make decisions when there is a shortage of information; there is a shortage of processing power? Because, remember that we had started by saying that Economics is the science of making decisions about how the society manages its scarce resources. When we are making decision and we do not have the processing power to make those decisions, how do we make decisions? We will also look at evaluation of natural resources.

The 12th module is case studies. We will look at the Economics of predicted areas and the Economics of environmental disasters followed by a summing up and discussion.

We will now touch upon how the society makes decision.

We have explored that there are certain basic questions of Economics: what to produce, how to produce, how much to produce, for whom to produce, when to produce and so on. Now, Economics helps us answer these questions and in this course we shall explore how these questions are answered, but the question is why do we have these questions in the first place.

We have these questions because the wants are unlimited, but the resources are limited. So, we want to have the best food, we want to have the best clothes, we want to have the best houses, the best vehicles, but our resource - in fact money - is limited. So, you have to make a choice. Do I want to have the best house and go with a not that good car or do I want to have the best car and live in probably a not so good house?

So, wants are unlimited, but resources are limited - which leads to a conflict. You need to make a choice because there is scarcity; there is a limitation on the society's resources both at an individual scale and at the scale of the society, which is why we need Economics to help us understand or study how the society manages its scarce resources - how you make this choice.

When we talk about scarcity, we have a trade off at all points of time. Whether you are thinking about it or not you are doing a trade off at all points of your living life. For example, now you are watching this video - you could have spent this time not watching this video and you could have spent it, say, watching a movie. Or you could have gone out with your friends, or probably you could have read a book, or probably you could have been working somewhere.

Now when you are watching this video you have given up all of those. So, there is this trade off - you are giving up something to get something and such a trade off is always there at the individual level. And it is also there at the society level. We have this classic thing that is known as guns versus butter debate. Should a society spend its resources on national security that is guns - or on consumer goods that is butter.

Why? Because if we talk about two things - you have factories that can produce aircraft and you can use this factory to produce fighter aircraft or you can use it to produce commercial aircraft. Fighter aircraft is your guns and the commercial aircraft is your butter or a commercial good. If the factory is being used to produce only the fighter aircraft that is this point, at this point the number of commercial aircraft that we have is 0. On the other hand, if the factory is producing only commercial aircrafts then the number of fighter aircrafts is 0 or the society could decide some other point so the society might say that we will have these many commercial aircrafts at this line and we will have these many fighter aircrafts.

Or the society could choose a point like this or else or the society could choose a point like this which is probably outside of the capacity of our industry. So, things such as these questions - whether to go for the fighter aircraft or the commercial aircraft - lead us to things known as production possibility frontiers. This line is the production possibility frontier.

It is giving us the option that if we were to use our factory to the fullest extent, we could choose any point on this line. If we choose a point like this, at this point we are making less number of commercial aircrafts and less number of fighter aircrafts then is possible. If we choose this point then we will have more commercial aircrafts and more fighter aircrafts as compared to this point, but if you choose a point outside then this is outside of our ability, we cannot have this point. So, this is the production possibility frontier.

When we talk about the trade-offs we have the trade-off between guns and butter, we have the trade-off between efficiency and equality. Efficiency is the property of society getting the most it can from its scarce resources. Equality is the property of distributing economic prosperity uniformly among the members of the society. When we talk about this debate, we are asking the question that there is an industry and in this industry we are making, say, biscuits. Now, these biscuits can be made using either machines or they can be made using labour. If you use machines, then probably the efficiency will be very large - the factory will be churning out a huge quantity of biscuits. This is efficiency. But in that case only the factory owner will be earning all the profits because there is no other person to share the profit with. This will create an unequal society. On the other hand, we could say that only labour intensive factories can be permitted. In that case we will have only labour because of which we will be having less number of biscuits that are produced. The efficiency goes down, but now the profit is shared by so many people and the equality is high. Economics helps us choose whether we want to go with more efficiency or more equality. And we have things like taxation and subsidies that promote equality at the cost of efficiency; there is always this trade off.

When you have trade-offs you also have cost. Cost is something that you give up to get something. When you are watching this lecture you are not able to watch a movie. So, the movie is the opportunity cost of watching this lecture. Because we have a trade-off we have a cost. And when we have costs then these costs can be explicit or implicit. Explicit cost is something that requires an outlay of money that is if you say that you want to buy a box of pencils or a bar of butter what is the money that you will have to spend. Implicit cost is a cost that does not require an outlay of money. That is, what you could have earned in a part time job, if you were not listening to this lecture. So, we have different costs.

When we talk about Economics we assume that people are rational and rational people are those people who systematically and purposefully do the best they can to achieve their objectives. That is, when we say that a person is rational then this person is trying to get all the information that he or she can, trying to process it in such a manner that they maximise their welfare and reduce their cost.

When we say that a firm is doing profit maximisation, we will say that the firm is a rational firm. In this context when you talk about rational thinking - a large quantum of it occurs at the margin.

Margin means what is the incremental change - a small incremental adjustment to a plan of action - that is margin. Marginal change is a small incremental change and a good example is, if you think about yourself, how do you think? Should I study 8 hours for the exam or not study at all? Do you think like this? Because everybody knows that if you do not study for the exam at all, you will probably fail. So, nobody thinks like this. But we normally think like this that should I watch my favourite TV show for 30 minutes and study 7 and a half hours for the exam. In place of 8 hours now we are thinking not about 0 hours, but we are thinking about 7.5 hours because whether I study for 7.5 hours or 8 hours will not make that much of a difference.

When we are thinking like this we are doing a rational thinking at the margin and a lot of rational thinking actually occurs at the margin. For example, if you talk about an airline and suppose the cost of flying a 200 passenger jet is 10 lakhs of rupees. The average cost of flying per passenger is 10 lakhs divided by 200, is 5000 rupees. Now, suppose the plane is about to take off and there are 5 seats that are remaining and there is a passenger who is willing to pay only 3000 rupees for that seat. Should the airline sell the seat for 3000 rupees or not?

If we think about an average thinking then we will say that no we are selling the tickets for an average of 5000 rupees and this person is paying 3000 so, we should not sell it. But, what happens actually is that airlines - if they are rational thinkers - they start to think at the margin. What is this marginal thinking? The airlines would think that ok what is the marginal cost of putting this extra passenger, because in any case the aircraft is about to take off.

Now there are two choices. We have choice 1 that is take off without this passenger and in this case the earning is rupees 0 because in any case the flight is going to take off. The choice 2 is to get rupees 3000 from this passenger and allot a seat.

Now, once you have this extra passenger on the aircraft, then it will also incur certain costs because there will be an increase in the weight. Now, one person on an average is like 60 - 70 kgs. So, what is the additional amount of fuel that will be required for this particular passenger? Let us say the additional amount of fuel that is required is 500 rupees because in any case you have this aircraft that is weighing several tons and this aircraft is going to take off. If you add 60 - 70 kgs extra then the change in the extra fuel will be very less say 500 rupees. When this passenger is there in the aircraft you will probably serve him with a bag of peanuts or certain snacks. What is the cost of that snack? Suppose the cost of this snack is 100. In this case the aircraft will be earning 3000 rupees. So, this is the revenue and the cost is rupees 500 plus rupees 100 is rupees 600.

In this case what is happening is that the marginal profit - should the aircraft permit this extra passenger - is 3000 minus 600 rupees is 2400 rupees. If the passenger is not permitted the aircraft the airline will not earn this profit, but with the extra passenger the airline will earn this extra profit. And, even though this is less than the average cost of selling the ticket, the airline will

probably permit this passenger because permitting this passenger is giving the airline an extra 2400 rupees.

What is wrong with that?

Now, this is marginal thinking that while on average the person is paying less than what the airlines charge, but marginally the airline is at a profit. And, so, taking a rational decision the aircraft should fly with this passenger.

To sum up when we talk about making decisions there are three important principles: one - people and society face trade-offs because there is a shortage of resources. Our wants are unlimited and so, there is a trade off. These trade-offs lead to cost and cost is what you give up to get something and what you are giving up could be in the form of money. Like you are giving up 50 rupees to buy a pen. That is the cost of this pen. Or probably you are giving out something else. Probably if you are not buying this pen you would have spent that 50 rupees on an ice cream. So, we can also say that the cost of this pen is the ice cream that you have to forgo.

So, cost is what you give up to get something and here you can also talk about the opportunity cost which is the next best alternative that you are giving up. When you say that you are giving up the ice cream that you wanted so much, then that is the opportunity cost of buying this pen.

We also saw that rational people think at the margin. Rational people are those people who take all the information, who process all the information to get to a point where they maximise their welfare. And, when they try to maximise their welfare they often think at the margin - that is small incremental changes. When the factory is thinking at the margin, the factory is asking the question should I produce one extra good? I have already produced 10000 cars. Should I make the 10,001th car?

When the buyer is making a rational choice thinking at the margin, he is asking ok I have had four chapati's should I eat the fifth chapati or not, and a lot of rational thinking happens at the margins. So, that is all for today.

Thank you for your attention. Jai Hind!

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Module 1
What is Economics?
Lecture 2
Interactions

Namaste! We move forward with our discussion on module 1, What is Economics. And in this lecture we will carry forward our discussion on Making Decisions and we will also have a look at Interactions. So, let us begin with a summing up of what we saw in the previous lecture.

In the last lecture we discussed about how we make decisions - how does a person make decisions and how does a society make decisions, and we surmised certain points about it. The first one being that people and society face tradeoffs. Whether it is at the level of an individual or it is at the level of the society there are always certain tradeoffs. What is the tradeoff? A tradeoff is something that because your resources are limited you can use your resources to get say object 1 and if you use your resources to get more and more of object 1 you will get less and less of object 2. A simple example is that suppose we have 2 objects - we have ice creams and we have chocolates and we have a limited amount of money with us. Suppose we have 100 rupees. Those 100 rupees can be used to get ice cream or they can be used to get chocolates.

If you spend your 100 rupees only on ice cream you will get 0 amount of chocolates. If you spend your 100 rupees on getting chocolates you will get 0 amount of ice cream or you can use your 100 rupees to get some chocolates and some ice creams. This is a tradeoff that we are facing at the level of an individual. Similarly society also faces certain tradeoffs primarily in the form of, what to produce, how to produce, how much to produce, whom to produce and so on. For instance, the society can utilise its resources to produce capital goods or it can use them to produce consumer goods.

The society can decide that we should put more and more amount of money into defence or it can decide that we should put more and more amount of money into health care or education. Because the resources are limited if we put more amount of money into say health care we will have less amount of money that is left for education sector. There is always a tradeoff. People and society face tradeoff primarily because the resources are limited. Because of these tradeoffs we have costs. Costs are defined as what you give up to get something.

So, what is the cost of say ice cream? If you are getting a big tub of ice cream for 100 rupees you can see that we have a cost of ice cream to be 100 rupees, but this cost can also be in terms of say time, it can be in terms of effort, it can be in terms of money, it can be in terms of certain other goods. So, for instance in place of having say 100 grams of ice cream you could have had that 200 chocolates. So, you can also say that the cost of 100 grams of ice cream is 200 chocolates.

In Economics we are always concerned about costs - what you give up to get something. And a very major cost that we need to consider is the opportunity cost, which is the cost of the next best thing that you could have had. The 3rd point that we considered was that rational people think at the margin. Economics thinks or Economics considers that people are rational.

Now, who is a rational person? A rational person is one who does all sorts of computations, keeps all sorts of information that he can have access to in his mind, before taking a decision - to optimize the decision for his or her own benefit. That is a rational person. Economics considers that people are rational. So, Economics considers that people are not taking a decision just out of nothing.

Whenever people make any decision they think about it rationally and such rational people are always thinking at the margin. When we say thinking at the margin we are saying that we are not thinking about whether I should use my 100 rupees to get only ice cream or whether I should use my 100 rupees to get only chocolates, but what we are thinking at all points of time is that suppose I have had 50 grams of ice cream should I spend my remaining 50 rupees on getting more ice cream or should I spend it on getting some amount of chocolates.

Because there is a certain amount of satisfaction that, I have already had by having 50 grams of ice cream. So, for the next 50 rupees will 50 more grams of ice cream give me more amount of satisfaction or getting certain chocolates will give me more amount of satisfaction, is something that I am always considering. This is what we mean by saying that rational people think at the margin. So, these are 3 things that we saw in the last lecture.

And in this lecture we will continue with this discussion on, how people and society make decisions. Now, an important point in making decisions is incentives. People respond to incentives. Incentive is something that induces a person to act. This inducement can be to act more or it can be to act less.

For instance if you get, say, a subsidy to start an industry you will be more inclined to start the industry, as compared to a situation where you were facing a large amount of taxation if you started an industry. So, this taxation or subsidy is an incentive that is being used by the government to induce people to do something. Another example is that in the case of cigarettes the government taxes cigarettes heavily. Now, this tax puts up more amount, or requires more amount of resources to be put in for a single pack of cigarette. And this is done so that it acts as a

negative inducement. The government does it so that people spend less amount of money or resources on getting cigarettes because cigarettes are bad for health.

So, the government can use a reward such as a subsidy or a punishment such as an excessive taxation to induce people to do something or to refrain from doing something. So, incentive is something that induces people to act in certain ways. Other examples are practicing hard so that you may win the Olympic gold medal. The incentive here is the Olympic gold medal and to get to that incentive or to get to that reward you are trying to practice more and more so that is an incentive.

Wearing a helmet for the fear of fine: here the fine is an incentive to induce people to act in terms of wearing the helmet. So incentive is something that induces a person to act. And, when we talk about incentives prices are a very major incentive in the economic system.

Prices act as incentives. How do prices act as incentives? Suppose the price of apples increases. You are using different fruits - you are using different food items and out of those food items the cost of apples has gone up. How will you respond?

There will be a certain amount of response. Probably because the apples have gone up in price you will start to consume less and less amount of apples. Or probably if you are, say, a shopkeeper, you will think that ok, the price of apples is going up so let me buy more and more apples. And I should store them so that after some time when the price goes up even further I will sell them off at a profit.

So, the price of apples is acting as an incentive for a consumer to have less and less - to consume less and less, and for the seller to hold more and more.

Suppose the price of apples increases, and the consumers try to reduce their apple consumption by, say, shifting to other fruits. So, you might say, ok, the price of apples is more I will consume less amount of apples; I will have more amount of oranges.

Producers may try to increase their apple production by, say, increasing the number of workers that are employed. Because apples are fetching a larger amount of price in the market it is going to lead to larger amounts of profits. So, the producers may try to increase their apple production. And how do they increase their apple production? By increasing the number of workers employed, or, say by getting newer machinery, or say by putting more and more amount of their land into apple production.

These are the kinds of responses that we are seeing just because the price of apples has gone up. So, the price in this case has induced persons - both the consumers of the product and the producers to act and so price is an incentive in this example. What we are saying here is that

incentive is something that induces people to act and prices in the economic system are very good incentives.

Now let us look at another example: there is a rise in the price of crude oil. Here again we are looking at the price of crude oil as an incentive. What sorts of behaviours will we see if the price of crude oil goes up? Here are some news articles relating to the price of crude oil and how people shift their actions.

The first one is "fuel prices impact daily use items like soap shampoo biscuits to become 5 to 8 percent more expensive." What is happening here is that because the price of crude oil has gone up, so a number of articles that require crude oil or its products for their manufacturing - say plastics, or for say energy use - which includes a number of other consumer goods become more expensive. The price of plastics will go up, the price of energy will go up, the price of transporting things will go up, and when all these prices go up, ultimately the price of the final produce will also go up.

This news article is saying that the fuel price impact is likely to make soap, shampoo, biscuits and other consumer goods more expensive. So how do people act? This news article says big rise in South Africans turning to credit as high fuel prices and cost of living bites.

One response is that I have less amount of money, but I want to maintain the same amount of consumption. So, I will have to borrow this money from somewhere. So, more and more people start moving towards credit and so there is a big rise in people that are turning to credit as a source of funds.

Another thing is that the rising fuel prices could increase the mobile phone bills, because here again the mobile phones towers are fuelled by, say, diesel generators or by electricity. As the price of diesel will go up the price of electricity will also go up. Now, this article says rising diesel prices may hurt the telecom sector. Why? Because the cost of providing this service of telecommunications is going up because of the increase in the price of crude oil. If there is an increase in your cost and there is not a corresponding increase in your selling price, your profits will take a hit.

So, this says that rising diesel prices may hurt the telecom sector.

How will the telecom sector respond? Probably if it was having certain plans of expanding it will put the expansion plans on hold. Or probably it will even try to curtail its operations in certain areas where it is not getting sufficient amount of profits.

So, here again the price of crude oil is acting as an incentive. Rising fuel prices are affecting Swiggy, Zomato's delivery fleet, Ola and Uber drivers because here again the cost of providing

the service is going up. This next article says Uber and Ola drivers go on a strike; demand higher fares for rising fuel cost.

So, the increase in the price of crude oil is now incentivising Ola and Uber drivers to go on strike. Because they are seeing that their profits are going down and in these situations they would demand higher fares for the rising fuel costs.

Another thing that will come up is that people will start giving you a number of suggestions on how to manage your household budget in the times of rising prices. Because we saw here that because of increase in the price of the crude oil the cost of shampoo, biscuits and soaps and other things is also going up. So, another action that has been incentivised is that people who are experts, or who are ready to give you suggestions on how to maintain your household budget - they will come forward.

And what sorts of suggestions will they say? They are asking to track every expense; lower the unnecessary expenses. When the price is going up the amount of consumption will go down. Try to raise income. People will start to look for other sources of income. Go for lifestyle changes because the price is going up and your lifestyle cannot be supported by the same amount of income that you've had so you should try to change your lifestyle so that you are able to accommodate with lesser amounts of stocks. Lower the debt outflow because nobody knows how long this fuel rise will go up.

Another thing that we see is rising petrol and diesel prices give states windfall gain of rupees 227 billion. Now, what this is saying is that because the prices of petrol and diesel have gone up so the amount of money that the government will get in the form of taxes will also go up.

Now, so far we have seen that when the prices of crude oil are going up it is acting as a disincentive for a number of people because their cost of living is going up. But in the case of certain governments this might even lead to more and more amount of money that is coming up in the form of taxes. So, what will government do in certain in these situations? The government will use this money for, say, certain activities.

The government may come up with a new program of infrastructure expansion or the government will come up with a new program of providing money to people or of providing food grains to people so that people are also better off. So, rising petrol and diesel prices to give states windfall gain of rupees 227 billion.

Other kinds of impacts are "Furious French drivers to block roads in fuel price protest." Similar to what we saw in the Indian context that the Ola and Uber drivers are coming up in protest, we also see that the French drivers have come up in protest. What happens then? This is another news: Paris police use tear gas, water cannons as protests against rising fuel taxes turn violent.

So, a rise in the cost of living is now leading to violence. Then rising gasoline prices push Macron popularity down. This news article is saying that the popularity of the president is going down because he is not able to control the prices. This is another impact of the rise in the price of crude oil.

Then it says Transport: PM Philippe suspends the fuel tax rises. The government has now been induced to act - the government has been induced to lower the taxes, so that the price of fuel comes down. So, the increase in price of crude oil has not just acted as an incentive for normal people it has also acted as an incentive for the government to reduce the taxes. This is what we are seeing here, the prime minister is suspending the fuel tax rises.

Another impact is: French fuel price revolt boosted ethanol use, say industry officials. What we are seeing here is that when the price of crude oil is going up the price of petrol and diesel are going up so now people are shifting towards alternatives. One such good alternative is blended petrol. In the case of blended petrol the petrol is mixed with certain amounts of ethanol which is ethyl alcohol.

Now, because the price of petrol has gone up so now people are shifting to add more and more amount of ethanol and to shift towards a blended petrol. This is another act that has been induced - because of the price rise the ethanol is going up. Next news article says SUVs have become classier, but here is the big bump on the road - rising fuel price.

What this news article is saying is that people normally go for large sized vehicles such as the SUVs or the sport utility vehicles. So, they have become classier. But then because they are of a large size they have a large amount of weight. They are not that fuel efficient. And when the cost of fuel goes up - when the cost of petrol, diesel goes up - then there is an incentive for people to shift away from these petrol or diesel vehicles. So, here it says that there is a big bump on the road which is the rising fuel prices.

So, now people will shift away from these SUVs which are not that fuel efficient. This is another activity that has been induced by rise in the crude oil prices. What will be the impact? People are now shifting away from the SUVs, people do not want to have a vehicle that is putting a big strain on their budget. So what happens? The sale of automobiles goes down. This news article is saying price hikes and rising fuel rates slow September auto sales.

Because of the rising fuel rates people are now less incentivised to buy newer vehicles and so the auto industry is going towards a slump. When such a thing happens the auto industry might respond by, say, shifting to different category of vehicles or probably by laying off people. The auto industry might say, ok, people are not buying our cars; we are not having a profitable year, so we cannot afford to have so many employees. Or the auto industry can say that ok people are not buying these sorts of vehicles - why do not we give them an alternative, why do not we

give them certain vehicles that are more fuel efficient that people might be more ready to buy. This is another impact that we are seeing because of increase in the price of the crude oil.

This news article says weak consumer sentiment - no festive cheer for carmakers on rising fuel cost and interest rates. This is from November 2018. November is typically the time when we have festivals like Diwali and people generally go for a large amount of buying in those seasons. But this news article is saying that because of the increase in the fuel cost and because of increase in the interest rates people are not buying the vehicles as was projected earlier.

Next what happens? Gas prices send surge of riders to mass transit. This news article is saying that because people are coming to this conclusion that because of these large amount of fuel prices, we will not be able to afford our vehicle; we will not be able to afford the use of our vehicle to go to our offices or other places every day, so, people are now shifting to mass transit. Mass transit includes things like railways, roadways, or public buses.

This news article is saying that because of increase in gas prices people are shifting towards mass transit. So, the gas prices are acting as an incentive for people to act in a certain manner and in this case the action is to ditch their personal vehicles and to shift to public vehicles. Another article says as gas costs soar buyers flock to small cars. Because the larger sized vehicles are less fuel efficient so people have now been induced to act in a manner - they shift from larger cars to smaller cars. Or even to scooters and 2 wheelers because scooters and 2 wheelers are more fuel efficient as compared to the 4 wheelers. So, if the crude oil price rises then people will shift from cars towards scooters. And the industry may also respond by saying that ok the gas and the crude oil prices are high so let us give people things such as electric vehicles. This is another inducement that has been brought up by the increase in the price of crude oil.

Soaring petrol prices spark interest in electric vehicles. Camel demand up as oil price soars. Now, this is a different kind of a news, but here also it says the same thing. As the cost of running gas guzzling tractors soars even toed ungulates are making a comeback raising hopes that a fall in the population of the desert state's signature animal can be reversed. What is this saying?

It says that, because the use of vehicles has become more and more unaffordable, so; now people are shifting back towards the use of camels. This is another act that has been induced by the rise in the prices. We saw earlier that prices act as incentives and all these different examples are showing the same thing. Another one says that IndiGo faces rough flight as rising fuel cost and price war hurt. Here again in the case of airlines the fuel prices - when they increase, they increase the cost of operations. And this news article is saying that the airlines IndiGo is now facing a rough time because of the increase in the fuel costs.

How will the airlines respond? Rising fuel prices: IndiGo hikes fares and other private airlines

may follow suit. IndiGo in this case is saying that ok our cost of operation has gone up and we need to remain profitable so, this cost will have to be given to someone else and in this case this someone else is the consumer. So, because the price of fuel has gone up, the ticket prices also go up. In this case the increase in the price of the ticket for the airline will now act as an incentive for other people as well.

Delta airlines to increase fares, trim flights as fuel prices rise. Here is another act that has been induced. Not only do airlines increase their fares, but they also reduce operations on those sectors that are not that profitable. Because your cost of operation has gone up so to maintain your profitability you will either increase the fare or you will reduce your operations in certain areas or you will abandon plans of expanding.

This news article says Emirates working to stabilise cost after 42 percent increase in fuel prices. Here again Emirates airlines is trying to stabilise its cost - it is trying to gain money from some other sources so that it can remain afloat. EasyJet investors worry about rising fuel costs. When the price of fuel has gone up, the airlines are not that profitable, and if the airlines are not that profitable the investors who have invested their money in the airlines will also be induced to act in certain ways. They will start thinking - ok, now the airline sector is not doing that good because their cost of operations has gone up. My money is not safe - let me take my money and put it into some other sector. So, the investors might try to reduce the amount of investment that they have made in the airline sector and shift it to some other sector.

So, EasyJet investors worry about rising fuel costs and probably they will take their money out of the airline sector. This article from the economist says: Crisis, What crisis? The airlines are suffering, but the order books of Boeing and Airbus are bulging. So even though the airlines are suffering because their cost of operations have gone up the order books of the airplane manufacturers such as Boeing and Airbus are bulging. Why is that so? This is again a very similar thing that we saw in the case of vehicles. If SUVs have become less incentivising the companies will give you certain alternatives. They will give you electric vehicles - or they will give you small sized vehicles. Similarly when the price of fuel goes up the airline industries that are making the aeroplanes - they will give the airline certain alternatives.

These would be certain aircrafts that are more fuel efficient. And so when these companies give you an alternative which is more fuel efficient more and more airline companies will flock towards these newer models. And so the order books of Boeing and Airbus are bulging because everybody now wants to have these aeroplanes that are more fuel efficient. This is another act that has been induced by the increase in the price of the crude oil. That it is now inducing the industries that make the aircraft such as Boeing and Airbus to come up with newer alternatives of aeroplanes or aircrafts that are more fuel efficient.

This article says how rising crude prices will impact Indian oil industry. Upstream oil firms

could face a higher subsidy burden while any government move to cap prices will hurt the margins of downstream companies. This article says that in the case of the petroleum industry you have certain upstream oil firms and certain downstream oil companies. Now, the upstream oil companies are those that are either extracting this crude oil from the earth or they are those industries that are buying this crude oil from other nations. And, the downstream companies are those that are using this crude oil, processing it and selling off things like petrol diesel kerosene LPG and so on. Now, this article is saying that the upstream oil firms could face a higher subsidy burden because the price of crude oil is now going up which means that the product that they are selling has increased in its price. So, their profits might go up whereas, the downstream companies - because crude oil is a raw material or a resource for these companies and they are selling off other things such as petrol and diesel, so, if the price of petrol and diesel also increases commensurate with the increase in the price of the crude oil then these downstream companies will remain afloat, but if the government tries to reduce the prices of petrol and diesel then these companies might take a hit. So, different players in the oil market will respond in different manners - the upstream companies will respond differently and the downstream companies will respond differently. So, what will be these responses?

Refiners look at cutting inventory as oil prices rise. Refiners are the downstream players. What they are doing is, they are trying to cut the inventory. They are trying to reduce the amount of crude oil that they are purchasing and they are using more and more of their inventory - the stocks that they already have because they do not want to put more money into crude oil at a time when the price of crude oil is already high. The refiners must pay for their crude oils in dollars and the soaring import costs are becoming ahead. In this case this news article says that the refiners are trying to cut in the inventory. Whereas the upstream players will try to increase the fuel storage. Why? Because this is a time when the crude oil prices are going up so the upstream company will think that ok, why don't I take more and more of this crude oil from the Earth - because the prices are going up!

So, it is incentivising the upstream companies to extract more and more of the crude oil or to procure more and more of this crude oil in the hopes that because of these rising prices they will sell them - sell this crude oil off at a larger price and at a larger profit. So, the upstream companies are trying to increase the fuel storage.

Another incentive or another act that has been induced is that solar beats oil and gas price in EU. Because the oil and gas prices are going up - because the crude oil prices are going up, so now the industry is looking at alternatives and one such alternative is solar panels, or solar energy.

With the carbon price set by the blocks emission trading scheme on the rise along with fuel - fossil fuel costs there has never been a stronger economic case for renewables. So, the act that has been induced in this case by the increase in the price of crude oil is that it is incentivising the industry to shift towards the renewable sources of energy.

The energy industry will shift from oil based or gas based power stations to more and more of say solar energy based stations or wind energy based stations or geothermal energy based stations or even say nuclear power stations because the price of crude oil is going up. And every industry is trying to reduce its cost so as to maximise its profit. So, this is another act that has been induced by the increasing price of crude oil which is more and more incentivising towards shift to a renewable source of energy.

Rotten potatoes - that is the governments answer to your rising fuel bill. Here again what it says is that while the government is hoping the rally in global rates declines soon, it is also looking at alternatives and in this case the alternative is ethanol. So, what we have seen so far is that people and society respond to incentives; incentives are those factors that induce people or society to act in certain manners. And in the case of Economics price is a very good incentive. So, if the price of something goes up we will see a large number of actions by different players.

Now, let us now look at interactions in the society. The first thing that we can discern from interactions is that trade can make everyone better off. What this says is that consider a society in which people do not trade. Everybody is trying to produce everything that he or she needs. In this primitive society suppose there is a person - she would have to grow her own food crops, she would have to raise her own cattle to get meat and milk, she would have to raise her own fibre crops, she would have to harvest all of these, she would have to make her own cloth, she would have to say make her own implements and so on; because this society is not a trading society.

So, everybody has to do everything. Now, in such a society suppose we bring in trade. When we say that we are bringing in trade what we are saying is that, suppose there are two people you and me and I am good at cultivating crops and you are good at, say, raising cattle. So, I might say that ok I am good at cultivating crops which means that my cost of cultivation is less than what it would have been if you were cultivating. Suppose in 1 hour I can grow 1 kg of wheat whereas, in 1 hour you can only grow 100 grams of wheat, whereas, your specialisation is in raising cattle. So, in 1 hour you can say produce 1 kg of milk whereas, I can only produce 200 grams of milk.

In such a situation if I were to spend say 8 hours of my day into 4 hours of making the wheat and 4 hours of making milk. How much amount of wheat and milk would I have? In 4 hours I will have 4 kg's of wheat and in 4 hours I will only have 800 grams of milk. On the other hand in your case you are also doing the same thing.

What we are saying here is that for me my rate of production is 1 kg of wheat per hour and 200 grams of milk per hour. For you the productivity is 1 kg of milk per hour and 100 grams of wheat per hour. Now, suppose in the first case - case 1 both of us are devoting 4 hours for wheat and 4 hours for milk. How much amount of wheat do I have in 4 hours? It is 4 times 1 kg is 4 kg of wheat and 4 times 200 grams which is 800 grams of milk. Whereas, you in 4 hours you have

made 4 into 1 kg which is 4 kg of milk, but only 4 into 100 grams which is 400 grams of wheat.

This is the first case in which we are not trading. You are producing both wheat and milk for your use and I am also producing wheat and milk for my own use. And both of us are devoting 8 hours into these activities.

Now, let us look at the 2nd case. Case 2 is with trading. In this case what I do is - because I can make more amount of wheat per hour as compared to you so let me use all 8 hours to make wheat only. So, I have 8 hours into 1 kg is 8 kg of wheat, and I spend 0 hours for milk which gives me 0 gram of milk.

In your case you are using 8 hours to make milk. So, you get 1 kg of milk per hour so you have 8 kg of milk and you spend 0 hours to make wheat and in this case you have 0 grams of wheat.

In the first case the total production in the society was 4 kg of wheat and 400 grams of wheat, which is 4.4 kg of wheat and 4 kg and 800 grams which is 4.8 kg of milk. This was the total production in the society in case 1.

Whereas, in case 2 we will have total production in society is 8 kg of wheat and 8 kg of milk. So, what we are seeing here is that if both of us were to do only those things that we had a certain amount of specialisation in then we would be able to produce more amount of resources with the same amount of input.

In the first case you were working 8 hours I was working 8 hours, in the second case also you are working 8 hours I am working 8 hours. But in the first case the total production is less than 5 kg of wheat and less than 5 kg of milk for both of us combined. Whereas, in the second case it is 8 kg of wheat and 8 kg of milk. Out of this 8 kg I keep 5 kg with me and I give 3 kg to you. What do you do? Out of 8 kg of milk you keep 5 kg with you and you give 3 kg to me. Now, at the end of the day I have 5 kg of wheat and 3 kg of milk, this 5 kg of wheat is what I produced and I kept with myself in this 3 kg of milk is what you had given to me.

And you have 5 kg of milk and 3 kg of wheat. Let us compare this situation 5 and 3 with the earlier situation in case 1.

In case 1 you are only having 4 kg of milk now you have 5 kg of milk. So, the total amount of milk so that you have is more. Earlier you had 400 grams of wheat, but now you have 3 kg of wheat. So, the amount of milk that you have is more than what you had earlier; the amount of wheat that you have is more than what you had earlier.

In my case, I have now 5 kg of wheat whereas, earlier I only had 4 kg of wheat. So, the amount of wheat that I have now with trading is more and similarly earlier I had only 800 grams of milk

whereas, now I have 3 kg of milk. So, the amount of wheat and the amount of milk that I have now is more than what I had if we had not traded.

What we are trying to emphasise here is that because of trading your amount of milk and wheat has gone up and my consumption of milk and wheat has also gone up. So, you are in a more beneficial position and I am also in a more beneficial position.

So, trade is something that can make everyone better off. And why does that happen? This happens because competition permits everyone to specialise in what they have the highest comparative advantage in.

In the case of trading because none of us is constrained to make everything; so, we can focus all our time energy and resources into making those things for which we have the highest comparative advantage. What is the comparative advantage? It is the ability to produce a good at a lower opportunity cost than another producer.

In this case I was able to make 1 kg of wheat per hour and you were able to make only 100 grams of wheat per hour. So, in this case I have a comparative advantage in the case of wheat whereas, in the case of milk I was only able to produce 200 grams per hour, but you were able to produce 1 kg per hour. So, you have a comparative advantage in the case of milk. Comparative advantage is the ability to produce a good at a lower opportunity cost than another producer.

Now, let us look at the opportunity cost: opportunity cost for wheat. For me the opportunity cost of wheat is 200 grams of milk per kg of wheat. So, if I spend 1 hour to produce wheat I will there will be 200 grams of milk that is less available for me. For you the opportunity cost of wheat is 1 kg divided by 100 grams which is 10 kg of milk per kg of wheat. If you look at this portion to make 1 kg of wheat you had to give up 10 kg of milk and so forth. So, my opportunity cost is less my opportunity cost is only 200 grams of milk your opportunity cost is 10 kg of milk.

Because my opportunity cost is less so for the case of wheat it makes much more sense that I should be making that.

Now, let us look at opportunity cost of milk. Now, for me the opportunity cost of milk is 1 kg of wheat divided by 200 grams of milk which is 5 kg of wheat. To produce 1 kg of milk I would I will have to forgo 5 kg of wheat. Whereas, in your case to make 1 kg of milk you only have to forgo 100 grams of wheat per kg of milk. So, in the case of milk your opportunity cost is only 100 grams whereas, my opportunity cost is 5 kg of wheat. So, you have a comparative advantage when it comes to milk and trading would say that you should concentrate more and more of your time and resources in producing milk because you have a comparative advantage in producing milk; whereas, I should spend more and more amount of time, money and resources into production of wheat because I have a comparative advantage.

If both of us focused on what we had a comparative advantage in the society would benefit because all the things will be made at the least possible cost. So, competition permits everyone to specialise in what they have the highest comparative advantage in.

When you are only producing milk and I am only producing wheat it also leads to an increase in efficiency. Efficiency is the property of society getting the most it can from its scarce resources.

In this case the resource is time. The society - which only comprises of you and me in this example - has only 8 hours for you and 8 hours for me. Earlier the society was able to produce 4.4 kg of wheat and 4.8 kg of milk whereas, now the society is able to get 8 kg of wheat and 8 kg of milk. What is happening is that the efficiency of the society has gone up for 1 day. In 1 day earlier it was only getting 4.4 kg of wheat and 4.8 kg of milk whereas, now it gets 8 kg of wheat and 8 kg of milk.

So, the efficiency has gone up for the society as a whole. At the same time specialisation and efficiency reduce prices benefiting the consumers. So, because there is a specialisation - you are only focusing on one thing I am only focusing on one thing - the efficiencies have gone up.

This ultimately benefits the consumers as well because they will be able to get all the resources at the lowest prices. In this example both of us are both the producers as well as the consumers, but we can extend this example to the actual society as well. People can get different items at reduced prices through trade as against different items at high opportunity cost when not trading. Thus trade increases welfare. When we talk about interactions in a society - economic interactions in a society - we need to remember that if there is trading in the society then everybody is much more well off as compared to a situation when there was no trading. So, trade makes everyone better off.

But how do we trade? In this example because there are only 2 people and there are only 2 things so it is easy for both of us to sit down and negotiate, that ok I will give you 3 kg of wheat and you will give me 3 kg of milk. But then in the case of a larger society all the different producers and all the different consumers cannot sit together and so we come up with the concept of market.

Markets are usually a good way of organising economic efficiency. Market economy is an economy that allocates the resources through decentralised decisions of many firms and households as they interact in the market for goods and services.

What is the market economy? It is an economy that allocates resources, in this example the resource that is available is time or the number of hours that are put in. In the market economy both of us are taking the decisions based on the most efficient way of producing the goods.

An economy that allocates resources - in this case the time - through decentralised decisions: Now why are these decentralised decisions? Because there is nobody who is telling us that we should be doing this, it is just you and me who are sitting together and deciding that I should make more and more of wheat you should make more and more of milk. The government is not telling us that. There is no person outside of you and me - outside of the producers and the consumers - that is deciding on how much amount of resources should be allocated - so this is a decentralised decision.

The market economy allocates resources through decentralised decisions of many firms and households. In this case there were 2 producers - you and me and there were 2 consumers - you and me. In the case of a larger society - a larger market - there will be a number of firms and households and they will all interact together in the market. And there are 2 kinds of markets; markets for goods and markets for services.

When all these decisions are happening in a decentralised manner through interactions then we say that this is a market economy.

Markets are a good way of organising economic activity efficiently, because in the case of markets prices and self interest guide decisions which leads to a large autonomy. In this case when we were talking about wheat and milk we were not taking this decision based on - say - benevolence. I was not thinking that ok you should benefit and so you should be doing such and such things. You were not thinking about me. Both of us were thinking about ourselves only.

I was thinking that without the trading I was getting 4 kg of wheat and 800 grams of milk. With trading I will get more amount of wheat and more amount of milk. So, this interaction or this specialisation is beneficial to me and this is why I am ready to get into this arrangement. So, this is for my own benefit - for my own good.

Similarly in your case also earlier you were only getting 4 kg of milk and 400 grams of wheat whereas, now you get 5 kg of milk and 3 kg of wheat. So, it is good for you and because of this reason you are getting into this arrangement.

In the case of market the prices and the self interest are guiding the decision. A market ensures that because both of us are benefiting so we will wholeheartedly participate in this decision. There is a large amount of autonomy that we have because nobody is forcing us to take this decision. We are taking these decisions out of our own sweet will.

Market prices reflect the value of good to the society and also the cost to the society in making that good. The value of the good and the cost of the good is reflected by the market prices. What we saw here was that this is the market price and this is reflecting both the value and cost of the

product. Because in the case of wheat I will think that ok for making wheat I need to give up 200 grams of milk and this is also the cost that I am putting in. Similarly you can also have an indication of the value and the cost to you. For you the cost of milk is 100 grams of wheat whereas, in my case the cost of milk is 5 kg of wheat. So, in this case what will happen is that my value for milk is much greater - my value of milk is 5 kg of wheat. Your value of milk is 100 grams of wheat. Because I value milk much more than you do so if you give milk to me - it will benefit me much more then it will harm you and this is also giving me an indication of the cost.

So, looking at the value and the cost through prices both of us can make a rational decision. There is an automatic transfer of information regarding demand and supply. Why is it automatic? Because if the price of something is going up it means that the demand is going up or the supply is going down.

As you saw in the case of the market for crude oil: if the price of crude oil is going up it is also telling us that the supply is less, because of which the information gets passed on to both the producers as well as the consumers. The consumers will use this information to reduce the demand by using less and less amount of the products of crude oil, such as petrol by shifting to, say, more fuel efficient vehicles or shifting to, say, renewable energy. Whereas to the producers it will give the information that the supply needs to be increased. And market's invisible hand leads firms and consumers to desirable outcomes as against a certain central planner making the decisions.

Here it is important to note that if we think about a central planner the central planner will also have a dearth of information and it will also have a dearth of the resources to process the information. In the case of a market because the decisions are happening automatically the information is getting processed automatically, so it is much more efficient.

To sum up we saw that in making decisions people in society face tradeoffs which lead to cost. Cost is what you give up to get something. We also saw that rational people think at the margin. People respond to incentives. And we also looked at interactions - that trade can make everyone better off. And markets are a good way to organise economic activity. So, this is a summing up of what we have seen so far.

That is all for today. Thank you for your attention. Jai Hind.

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Module 1
What is Economics?
Lecture 3
Working of the Economy

Namaste! We move forward with our discussion on the principles of Economics. In this lecture, we will look at Interactions and the Workings of the Economy. Before we move forward, let us recap what we have seen so far.

The first principle of economics is that people in society face tradeoffs. Now, tradeoffs arise because our needs - or our wants - are unlimited, but the resources to get those wants are limited. So, we always have to make a choice - whether I should get more of A or whether I should have more of B? Because I have limited time, I have limited resources, I have limited money and so, I cannot have all of A and all of B.

A very easy example is the choice between having more ice cream or more chocolates. The more and more amount of money I put into getting ice cream, the less and less amount of money I have to have chocolates, and so on. We face tradeoffs on a daily basis at a personal scale depending on what we want to buy or say where to put our time into. Do you want to go out and watch a movie or do you want to go out and spend time with your friends? Because if you go and watch a movie you cannot chit chat with your friends at the same time. Your time is limited. Your time is a resource which is limited. So, we have a trade off in terms of money, we have a trade off in terms of time and these are not just at the level of the individual, but they are also there at the level of the society.

Whether the society should have more of consumer goods or whether it should have more and more of capital goods - for instance. Whether the society should put more money into defence sector or whether it should put more money into education sector, or say health sector? Whether we should promote - with the same amount of money that we have - should we promote primary health care services or secondary health care services or tertiary health care services?

These are all different tradeoffs that the society needs to make. So, the first principle is that people and society face tradeoffs, and these tradeoffs lead to costs. Cost is defined as what you give up to get something. Now, what you give up can be in terms of money, it can be in terms of

time, or it can be in terms of certain other products. So, for instance we can give a concrete example - we can say, that we have 100 rupees with us. These 100 rupees can buy, say 100 grams of ice cream, or say 200 chocolates. Now, the cost of ice cream - we can say that the cost of ice cream is 100 rupees. The cost of 100 grams of ice cream here is 100 rupees.

But, we can also say that the cost of 100 gram of ice cream is 200 chocolates because, we are either giving up 100 rupees or we are giving up 200 chocolates to get 100 grams of ice cream. We could even represent cost in terms of time. So, for instance if there is a labourer who works for one complete day and earns say 200 rupees, in that case the labourer might even say that the cost of 100 grams of ice cream is working for half a day. So, the cost of something is what you are giving up to get it, and what do you give up? You can give up money, you can give up time or you can give up certain other goods or resources. These are costs. The third principle of economics is that rational people think at the margin.

Now, one basic or one fundamental assumption that economics makes is that people are rational. And, by rational we mean that people make decisions consciously by taking into account all the information that they can have access to and they process this information. So, any decision that you make is not out of a jiffy, but you actually put an effort to make it a rational decision to maximise your utility or to maximise your benefit.

So, for example if you say that ok, I have had 70 grams of ice cream. Now I should have some chocolate. Because, I want to change the taste or because chocolates will give me much more satisfaction - because, I have already had a substantial amount of ice cream. We will say that you are making a decision. You are thinking about it, and so, this is a rational decision. Now, rational people and also a rational society - they think at the margin. When we say thinking at the margin, it means that we are not making a choice between 100 percent of A or 100 percent of B. But we are thinking that ok I have had so much amount of A. What should I do now? You are always thinking at the edge; you are always thinking at the margin. For example, a society might think that ok I have got three factories for making cars, should I make a fourth factory for making cars or should I make a fourth factory for making say television. This is a thinking at the margin. The society is thinking - or people in the society are thinking that ok we have had three factories, but we have more resources at our disposal. Should we spend those resources into making more of automobiles, or to make something else - given that we already have three factories. This is thinking at the margin.

Similarly, as we saw in the example before there is an airline and the cost - or the average cost - of selling a ticket or selling a seat on that airline is say 5000 rupees. Now, there is an aircraft that is ready to take off and there is a passenger who has just arrived and he says I cannot pay you 5000 rupees, I can only give you 3000 rupees. How should the airline make the decision? If the airline is not thinking at the margin the airline would say, I sell my tickets at 5000 rupees. You cannot give me 5000 rupees. So, I cannot give you a seat. But that would not be thinking at

the margin. Thinking at the margin the airlines would say that ok, if this one more person gets into the aircraft, there will be some excess cost - for certain amount of fuel - because we are adding certain weight of the passenger as well as his goods, plus we would have to serve this passenger, probably, say a bag of peanuts. The airline carrier, if it is thinking at the margin - it would do a cost computation. Of how much would this extra fuel and extra bag of peanuts cost the airlines. If the cost of taking this passenger into the aircraft and flying them is say 1000 rupees and this person is giving the airlines 3000 rupees. So, thinking at the margin the airlines would say ok let me make a profit of 2000 rupees, what's wrong with that? And so, even though the price is less than the average price at which the airlines is selling the seats, the airlines would sell the seat to this passenger for 3000 rupees.

So, a lot of rational thinking occurs at the margin, which is why whenever there is a product that is going to get expired soon, we see a hefty discount that is offered in shops or last minute bookings for aircrafts or last minute bookings for resorts. We see these phenomena because, these people are thinking rationally and they are thinking at the margin - they are thinking at the edge.

The fourth principle that we saw was that people respond to incentives. Incentive is the inducement to do something or to refrain from doing something. People respond to incentives. It means that if you want people to behave in a certain manner you should provide them with incentives. These incentives can be in the form of reward or they can be in the form of punishment.

For instance when a teacher says that if you do homework, and if you do it properly I will give you a chocolate - the teacher is offering a positive reward as an incentive to make the pupils do their homework properly. On the other hand, if the teacher says that if you do not do your homework properly I will give you a punishment. Then, here again the teacher is providing an incentive to the pupils to do their homework.

So, the incentive can be in the form of a reward, it can be in the form of a chocolate or it can be in the form of a punishment.

And, our societies regularly make use of incentives. When the government says that we are subsidising higher education the government is providing incentive to people to go for higher education. Because otherwise, their cost would have been larger and with the subsidy the cost is reduced. Or when the government says that ok we are going to put a heavy taxation on cigarettes. This is because the government wants people to refrain from smoking, because of its negative health impacts. And so, the government would put a heavy amount of taxation onto cigarettes. So that people refrain from putting their money into cigarettes.

This is a very important principle of economics: people respond to incentives. Throughout this

course, we will have a look at what sorts of incentives are provided by the government or by the society to make people respond in certain ways.

Then, we looked at interactions and in interactions, we saw that trade is something that can make everyone better off. This is because with trading we allow people to specialise into doing things that they have the highest comparative advantage in. Comparative advantage means that if I can make something at a cheaper cost than you, then probably I am in a better position to make that good. And in that case, the society would benefit if I made more and more of that good. Here again the important thing to note is that the cost of doing something is what you give up to do something else.

So, for instance if I can spend my time to grow wheat or to raise a dairy, and in 1 hour I can make say 1 kg of wheat or 100 grams of milk. And say, another person in 1 hour - he or she can make 1 say 200 grams of wheat or 500 grams of milk. Here we can see that I am at a much better position at growing wheat. Because, in 1 hour I can make 1 kg of wheat, and this person can only make 200 grams of wheat.

So, if I specialise in making wheat, I can spend more and more time in growing wheat and then our society will have much more amount of wheat than if both of us were doing both wheat and milk production. But here we can also see that when I do a computation for wheat, then the cost of making 1 kg of wheat for me is 100 grams of milk. The cost of 1 kg or the cost of making 1 kg wheat is 100 grams of milk. Whereas, for the second person the cost of making 1 kg of wheat is 2.5 kg of milk. So, I can make wheat much cheaper than the second person.

But then if I look at the cost of making milk - for me, it is let us say the cost of making 1 kg of milk. This will be 10 kg of wheat whereas, for the second person the cost of making 1 kg of milk - in this case is 1 divided by 2.5 is equal to 0.4 kg of wheat. Now, what we are seeing here is that, if I can make wheat at a cheaper cost it would also mean that I would be making other things at a much greater cost.

So, there is always a comparative advantage between two or more people. And trade makes everyone better off by permitting people to concentrate their resources - to concentrate their time, into making things that they have the highest comparative advantage in. And when we go on doing things that we have the highest comparative advantage in, with time we also specialise. We also develop means to make things even cheaply, and the benefit of making all these things with greater efficiency ultimately goes back to the society. So, trade is something that can make everyone better off.

We also saw that markets are a good way of organising economic activity. What is a market? A market is a place where buyers and sellers come together, and there is a democratised decision making. So everybody is making his or her own decisions based on his or her own benefits. In a

market - when you go to a market you will ask the question ok, I want to get a tub of ice cream - where can I get it at the cheapest rate -the best quality at the cheapest rate. When you make such decisions you go to a seller who is providing things at better quality and at a cheaper rate. And when you buy the things from that seller, you are actually promoting that seller to make more and more things at better quality and at cheaper rates.

Similarly, in the case of a market there is no third force that is making these decisions about whether I should have ice cream or whether I should have chocolates. I make decisions based on my own free will and all these decisions of different buyers and sellers in the market are reflected in the prices that we see in the market. So, market makes it very easy for buyers and sellers to make decisions based on the prices. And so, markets are a very good way of organising the economic activity.

Moving further into this topic of interactions another principle is that governments can sometimes improve the market outcomes. Now, the question is, if markets are a very good way of organising economic activity, do we need a government? Why should there be a government? Why should government be making certain decisions? The economic principle here is that governments can sometime improve market outcomes - because the market by itself may not always result in the most optimal solution.

What is a government? A government is the group of people with authority to govern a country or state. The important point here is authority. Authority means legitimised power. So, these are the group of people who have the power and this power has been given to them through certain legislations. They have a legitimate authority to govern a country or state. When that happens they can make certain decisions. For example, if you want to go into a market or say you are a seller and you are making say ice creams. In a theoretical market you would want to maximise your profit and to do that you want to make things at the cheapest possible way. So, you are putting a lot of money into innovation - you are putting a lot of money into getting the best machines. But then once you have invested a lot of money into your factories, somebody comes and burns your factory. Now, if such a situation arises would you want to put your money into all these innovations? The answer is no. Why? Because you are not sure whether your investments would give you a profit or not.

You are working for the profit - you are working in a self interest, but your self interest will only get fulfilled if you have a proper law and order that ensures that you will get your rewards. Who will ensure this law and order? That is the role of government. The government improves market outcomes by ensuring that the fundamentals for the working of the market are there.

So, how does the government improve the market outcomes? The need of government is for enforcing rules and maintaining institutions that are a key to the market economy such as police, judiciary, and so on. If you have a good law and order system with good police, good judiciary,

you will have much more faith, you will have much more confidence that the money that you are putting into innovation - that you are putting into making your factory will not go down the drain. So, the first need of government is to enforce rules and one such rule is that nobody has the right to destroy another's property. The government makes these rules and the government enforces these rules.

The government also maintains institutions because it is not enough that you have a rule. You also need to have an institution to enforce that rule. If you have a law, but you do not have police, if you do not have judiciary, then the law will just not work.

So the government not only makes the rules, but it also maintains the institutions that will play a role in enforcing these rules.

Similarly, the government enforces property rights. Now, what are property rights? The ability of an individual to own and exercise control over scarce resources, to own and exercise control. And this demands that thefts be minimised or obliterated. Property right is the ability of an individual to own scarce resources. Scarce resources could mean things like land or things like capital. You should have the power to own land, you should have the power to own capital, then and only then will you be able to have the power to set up a factory.

You wanted to make ice creams cheaper and you wanted to make ice creams with good quality. For that you need to have an industry, but you will only be able to have an industry, if you have the power to own land and the power to own capital.

Now, suppose in a society there is a rule that nobody will own any land or any capital, only there is one king who will own all the land and all the capital. In such a society - if you live in such a society, you will not be in a position to set up the factory. So, property rights give individuals the right to own the scarce resources and not just own but also to exercise control over those resources.

Suppose you live in a society in which there is a rule that land can only be used for agriculture, it can never be used for setting up an industry. So, even though you have the land - even though you have the capital, you will not be able to set up the industry.

So, for the working of the society or for the working of the market - so that you are able to produce things cheaply and in good quality, you not only require an access to the resources - you do not only require an ownership of the resources, but, you should also have the right to exercise control or to do something with your resources. And, government provides enforcement of these property rights - the right to own and the right to exercise control over the resources. That is the need of the government. If you do not have rules, if you do not have property rights, the market cannot function.

At the same time the government is also required to increase efficiency of the market by addressing market failures. What is market failure? A market failure is a situation in which a market left on its own fails to allocate resources efficiently. Now, what does that mean? The utility of market is that it permits allocation of resources, by choosing those sellers that are making things at a good quality and at lower cost. When you buy something - when you buy your tub of ice cream from a seller, who is selling it with a good quality and at a cheaper cost you are providing more and more resources to that seller or to that producer, so that he or she can make more and more of these things at cheaper cost and with a good quality.

Now, if you have a market and it is not able to allocate these resources, which means that there is a market in which you do not know who is the seller who is providing things cheaply and at a good quality, then this market will not be able to function. And so, a situation such as this would be known as a market failure. Market failure is a situation in which a market left on its own fails to allocate resources efficiently. Why would we have such a situation?

There are things such as externalities that can result in market failures. What is an externality? An externality is the impact of one person's actions on the well being of a bystander. The bystander is not doing anything - the actor is doing something, but his action is having an impact on the bystander. This is known as an externality.

A very good example is pollution due to the use of automobiles. Now, if somebody is driving a big sized SUV, then this person is not just driving the SUV and fulfilling his or her own requirements, but is also polluting the environment - because this SUV is giving out a lot amount of smoke. Now, this smoke will not just impact the automobile driver - it will impact the society in total because when the air is polluted everybody is impacted. And so, this pollution is an externality, because the action of an actor or the action of a doer in choosing to drive a vehicle which is giving out lots of smoke, is putting an impact on a bystander who has got nothing to do with this decision.

And things such as externalities may result in market failures. Why? Because the driver of this vehicle - the driver of this polluting vehicle is imposing a negative cost on other people - and he does not have to pay for those costs. So, for instance if I get ill because of air pollution, then I will have to pay my own medical bills - that person who is driving that polluting vehicle will not come and give me money to pay my medical bills.

If there was a mechanism to internalise this externality, then the results would have been very different. For instance if the society said that ok, if you want to drive a vehicle that is resulting in pollution, you will also have to pay for taking care of the health of all those people who are impacted by your decision to drive this polluting vehicle. If such a situation was there then this person who is driving this vehicle would have thought of his decision in a very different

way - because remember that this person is also a rational person. He wants to maximise his or her own utility - which means that he or she wants to minimise his cost and maximise his benefit. And there is nothing like giving the cost to somebody else.

If this person had to pay money to all these different people, who were impacted because of the pollution he would have thought ok, let me just get rid of this vehicle and get something that does not pollute so much. So, an externality can result in a market failure because, the person who is making the decision is not paying the full cost. An externality can also be a positive externality - a positive externality is say things such as vaccination.

So, if you choose to vaccinate your children, then you are not just protecting your children, but you are also protecting the society. Because, the pathogens will not be able to infect your children, multiply in their bodies and then spread to other children. So, vaccination is a positive - it has a very big positive externality.

Now, if you only had to protect your child and if the society does not provide you with an incentive for the benefit that the society is receiving, then your level of commitment to vaccination might not be that great. But then if the society says that ok if somebody is vaccinating his or her child, then because the society is getting a benefit, so let us as a society subsidise vaccination. So, if you have to pay a lower cost - if you get an incentive - then because people respond to incentives you would have looked at vaccination in a very different manner.

So, externalities may result in market failures because the cost or benefit of doing something is not coming back completely to the doer. And the government can address this market failure by giving out a mechanism to address these externalities, by say subsidies or taxation. And in that way the government will aid in increasing the efficiency of the market.

Because in that case the market - again remember that the market is a mechanism for the most efficient allocation of resources, for the benefit of everybody. Now, if the action of doing vaccination is benefiting the society, then there has to be a mechanism to incentivise vaccination. If pollution is impacting the whole of the society negatively, there has to be a mechanism to reduce the allocation of resources in pollution. And the government may set up a mechanism to internalise the externality so that the allocation of resources becomes much more efficient.

For instance in the case of pollution due to vehicles the government may increase tax on petrol or diesel, or may even tax the selling of these vehicles. If there is a tax on petrol or diesel or the vehicles, this taxation will increase the price of using these vehicles. Increasing of this price will result in an incentive, it will induce people to do something. And what will be that something? It may incentivise people to use car pooling. Because the cost of transportation has increased so people would say ok four of us are going to the same location, why do not we use just one car. Or it may incentivise people to take public transportation because the cost of using your own

vehicle has increased. So, there would be a certain section of the society who would ditch their vehicles and move towards public transportation, or which may incentivise people to live closer to the workplaces - so that they do not have to buy such a large amount of petrol or diesel - or to shift to fuel efficient vehicles. Especially if these fuel efficient vehicles also get a subsidy.

So, the government may increase taxation on the polluting vehicle and the government may provide a subsidy to those vehicles that are non-polluting or to shift to hybrid vehicles or electric vehicles for the same reason. Left to themselves without the government people may keep on driving the polluting vehicles, since the quantum of the harm gets diluted due to the externality - because you do not have to pay for the health of all those people who are getting negatively impacted because of the pollution.

But if the government internalises this externality by increasing taxation, then some portion of this externality will get internalised. And this will act as an inducement for people to go for carpooling, public transportation, living closer to the workplaces, or shifting to more fuel efficient vehicles or hybrid vehicles or electric vehicles.

So, this is a role of the government. By using these mechanisms of taxation and subsidies, the government addresses market failures and increases the efficiency of the market.

Another mechanism of market failure is market power. Now, what is market power? Market power is the ability of a single economic actor, or a small group of actors to have a substantial influence on market prices. And often this substantial influence is a disproportionate influence - the ability of a single economic actor or a small group of actors, to have a substantial influence on the marketplace - on the market prices. Good examples are monopolies - the owner of a single well in a village where there is a drought. Let us consider that there is a village that is suffering from a drought condition and there is only a single well in that village. Now, the owner of that well - because he sees that there is a huge demand - so, this owner might charge anything for taking out water from this well. If the owner charges at a disproportionate rate, then it will not be a benefit of the society. This will result in a market failure, because it is leading to an inefficient allocation of resources.

And such a situation will go on propagating itself, if the government probably does not interfere. Now, how can the government interfere? The government can do a number of things. The government can say ok, even if you have a single well in a village there is a cap that you can charge. So, for instance the government might say that ok, for one litre of drinking water you cannot charge more than 15 rupees. If this situation arises then even those people who did not have a very large amount of money with them - they would have access to water. Or the government might do another thing. The government might try to break this monopoly, by say digging up a well from government funds. Or the government might give out a subsidy - the government might start a program that would say that ok, if somebody wants to dig up a well we

will provide so much amount of capital. Or so much amount of money to each person to incentivise more and more people to start digging wells. Or the government might out rightly say that ok, because the situation is so bad - because this person is charging so high, let us nationalise this well. So, that this well is now no longer a property of this particular individual, it now belongs to the government - it belongs to the society.

So there are a number of things that the government can do in these situations, where you have a single economic actor or a small group of actors that are having a substantial influence on the market prices. They are having such a huge influence on market prices that it is not to the benefit of the society and it is not an efficient way of allocating resources. The government may break these market powers - the government may break these monopolies and increase the efficiency of the market.

Another thing that the government can do is to increase equality. We saw before that the society makes a tradeoff between efficiency and equality or equity. So, you can put your resources in such a manner that you maximise the production of goods, or you can also do things to ensure that everybody has a decent share of the pie. If you only wanted to increase efficiency the society might say ok, let us give all the resources to a few people who are doing things well. And, in that case they will have all the money, they will have all the power to do everything - anything and everything and rest of the people would live a life of poverty. Or the society might decide that ok, efficiency is important, but equality is also important; equity is also important. So, the society might say that even though there are certain people who are not doing things with the highest efficiency, but they also have the right to live. They should also have access to sufficient amount of food, sufficient amount of nutrition, sufficient amount of clothes, sufficient shelter.

When the society decides this - the implementation of such a policy comes to the government - because the government has the power to influence these decisions and to implement these decisions of increasing equality. The market by itself may not ensure sufficient food, decent housing and adequate health care to all.

If you just left it to the market the market might say that ok, we want maximum profit and so, we are only going to provide health care to those people who can pay for them. Or we want to maximise the profits out of vaccines. Now, vaccine is something that has a positive externality, because not only the person who is vaccinated is protected from the disease, but the society in total also gets protection because of herd immunity.

Now, if there is such a situation then the government might step in and say that ok, we cannot let things go on like this and we need to emphasise the quality. And so, we are also going to provide vaccines to those people who cannot afford them because the society benefits if those people also get access to the vaccines. So the market by itself may not ensure sufficient food, decent housing and adequate health care to all.

But the government may chip in - the government may provide for all these different resources. Now, equality is the property of distributing economic prosperity uniformly among the members of the society. And this is also a role of the government. There are two major ways in which government impacts these market outcomes. And these two ways are price controls and taxation. Price control means that the government may set up a price floor. A price floor says that this is the minimum amount that you have to pay to get this good or service, and a good example is the minimum support price that the government sets for food grains. When we have a price floor the government is saying that we cannot let the society exploit the farmers. And so, there is a minimum amount that needs to be paid to the farmers, so that they are able to carry on their cultivation, they are able to pay for say water, pay for fertilisers, pay for insecticides and so on.

The farmer should also be able to make all these payments and still retain a decent amount of money to meet the needs of his or her own family. And so the government may set up a price floor - this is the minimum amount that you need to pay to the farmer to get these food grains. In certain other cases the government may set up a price ceiling - this is the maximum amount that you can charge to a person. When you talk about things such as the rent control act, the government says that ok you cannot charge exorbitantly for providing accommodation to people, there is this maximum amount that you can charge - this is a price ceiling.

So, the government may use these price controls to put up a price floor or a price ceiling or the government may even come up with minimum wages. This is the minimum amount of money that you need to pay to a person to make use of his or her labour or services. This is the way in which the government can impact the market outcome.

Another way is taxation. Taxation can be direct taxation, indirect taxation or even Pigouvian taxation. We can even talk about negative taxation which is the subsidies. Now, direct taxation is a taxation that is directly taken from the person and in a number of cases this is, or say a very good example is, the income tax.

Income tax is taken directly from the person who is earning this income. Indirect taxation on the other hand is taken indirectly from those people who are making use of certain products. So, when we talk about sales taxes these are indirect taxes. We also have Pigouvian taxes. A Pigouvian tax is a tax that is not put up to earn revenue for the government, but is there to change the behaviour of people. A very good example is the tax on cigarettes or taxes on polluting vehicles. This is a tax which is not primarily meant to increase the revenue of the government, but is meant to change the behaviour of the people. So, this is also another way in which the government may impact the market outcome. So the government may act through price control, price floor, price ceilings minimum wages or through taxes and subsidies which can be direct, indirect or even Pigouvian.

Now, because the government is impacting the market outcome through these interventions - and we have seen before that markets are generally a good way of organising the economic activity - so, these interventions have to be used with abundant amount of caution. And, we will see how the government or the society may make use of these interventions for conservation purposes.

Next, let us have a look at the workings of the economy. The first principle in the working of the economy is that a country's standard of living depends on its ability to produce goods and services - that is the productivity that the country has. And productivity is defined as the quantity of goods and services that are produced from each unit of labor input. So, basically what this says is that if you have a country, if you have a society and the society is very highly efficient, it is able to produce a large amount of goods and services. Who will make use of these goods and services? The answer is the society itself. So, if you make more and more of goods and services, you increase your standard of living. Because then, everybody has access to more food, everybody has access to more comfort, everybody has access to more health care and so on. So, if you want to raise the standard of living of a country or a society the primary way of doing it is through increasing the productivity of that country or the society. We can understand it in this way that more production leads to more goods and services that are available to the society. More goods and services available to every person of the society means, a higher standard of living.

So, a country's standard of living depends on its ability to produce goods and services, which means productivity. Which means that if you want to raise the standards of living you have to raise productivity. And how can you do that? You can do that by these three ways.

You can provide education to people. By providing education you can shift certain people who are working in the primary sector or the labor intensive sector, into say an information sector. Now, in the information sector because there is a greater demand for those goods so, the persons will be earning more. And earning more would raise the standard of living. Or through education you can give people access to means that raise their efficiencies. So, in place of say doing all the work manually a person might shift to using machines. But then if a person does not know what a machine is or what sorts of machines can be used, or how can they be used the person might not be that incentivised to use those machines. Education provides people with the means to use these new technologies.

So, to raise productivity you should give or the society should give education to people. But just education is not enough. There should always also be a provisioning for the tools of production of these goods and services. So, for instance as a farmer - through education I have come to know that ok, I should be using tractors. But, then if my society just does not have any tractors how will I use these tractors? So, not only is education important, but you should also have access to these tools and equipments.

So, the society needs to put in certain amount of money for the production of these goods, which are known as the capital goods. You need to have production of tractors, you need to have production of computers, you need to have production of machines, you need to have production of lathes and so on. So, to increase productivity you provide education, you provide tools and equipments for the production of goods and services.

And also you need to put in money into the production of technology, which means that there has to be innovation going on in the society. So, for instance if all the farmers have access to education, and they have access to tractors. But, then it is also possible that you could tweak your tractors in such a manner that the efficiency goes on increasing even further. How will you come up with such tweaks? Through innovation, through technology. So, technology is also something that needs to be provided to increase the productivity of people. And this productivity will in turn raise the standards of living of the society.

Another principle of economics is that prices rise when the government prints too much money. The rise in prices is known as inflation. Inflation is an increase in the overall level of prices in the economy. Now, prices can be understood in two terms, one is in terms of money and the second is in terms of other goods and services. So, let us consider that there is a society which has only 2 goods.

The good 1 is wheat and the good 2 is milk. So, in this society we have only 2 goods, for the sake of understanding. And the wheat is being sold for say 30 rupees for 1 kg. And the milk is being sold for 60 rupees for 1 kg. Now, the thing is these are the levels of prices that are prevailing in the economy at present.

So, the level of prices: for 1 kg of wheat you have to pay 30 rupees, for 1 kg of milk you have to pay 60 rupees. Now, suppose the government prints too much of money. In place of having 100 rupees in the pocket of everybody the government has printed so, much of money that now everybody has 200 rupees. Let us think that just by magic everybody has 200 - has twice the amount of money that they had previously. Now, what will happen? In this situation the price of everything will increase. In place of having - we can also understand it in by saying that the price of 1 rupee is equal to 1 by 30 kg of wheat. And the price of 1 rupee in terms of milk is 1 by 60 kg of milk.

Now, if the money has just doubled magically because the government has printed so much amount of money, the price of one rupee will go down. So, in place of having 1 by 30 kg of wheat, now person might demand much more amount of money or much less amount of wheat. When the government prints too much of money the value of money decreases, because here again in the society the value of anything is determined by the demand and supply of that thing. If the supply of money has gone up, the value of money will go down. Now, if the value of money will go down, it would mean that for every rupee you will get less amount or less quantity

of goods than you were getting previously. Because earlier the value was large, so in exchange for money you were getting a larger quantity of goods; now the value has gone down.

So now you will get a smaller quantity of goods and so, more money is needed to purchase the same amounts of goods or services which increases the price of goods and services which leads to inflation.

So, the primary cause of inflation is that the value of money has gone down, because the government has printed too much of money. How will this show up? This will show up in this manner that earlier for wheat, you were paying 30 rupees for 1 kg. Now, you will have to pay 60 rupees for 1 kg. And for milk earlier you were paying 60 rupees. Now you will have to pay 120 rupees for 1 kg. The level of prices have gone up because you now have access to double the amount of money. But this is known as a notional increase in the prices. This is notional because this is only there in name. Because, if you look at the society earlier you would find that milk is worth twice the amount of wheat. So, for one kg of milk earlier - let us put it in writing. In the earlier situation for 1 kg of milk, you were getting 60 rupees, which is equivalent to 2 kg of wheat. This is in the earlier situation. But, then after inflation what happens?

After inflation we have a situation that 1 kg of milk is now worth 120 rupees. But, the price of wheat has also gone up. So, for 120 rupees you will get 2 kg of wheat. Earlier the price of 1 kg of milk was 2 kg of wheat, after inflation the price of 1 kg of milk is 2 kg of wheat. So, there is no actual change in the prices. The change in prices is only in terms of the rupee value or the money value, which is because the amount of money that is there in the society has gone up to such an extent that the value of money has gone down.

But, the value of all other things in terms of other goods and services, they will remain the same. So, the principle of economics here says that prices rise, when the government prints too much of money. This is something that we need to keep in mind whenever we are talking about inflation.

And then the last principle is that the society faces a short run tradeoff between inflation and unemployment. The question is should we have inflation in the society or not? The answer is slight amount of inflation is good for the society. Why is that? If you have more money in the economy - why is there more money in the economy? Because, the government is printing more money. If there is more money in the economy people will spend more. When people will spend more so, in the short run there will be a more demand for goods and services. Because, earlier you were having only 100 rupees so, you were spending 100 rupees. Now, that you have 200 rupees right away you will think ok, I have more amount of money let me buy more stuff.

Because, here again rationally you are trying to maximise your utility. And, because you have more access to resources you want to have more goods and services. So, in the short run more money in the economy will lead to more spending, which is more demand for goods and services. More demand for goods and services in turn would lead to inflation, because there is a

rising cost.

So, there is now more demand for milk and so, the cost of milk rises. But, then more demand for goods and services would also mean that now the milk man would want to have more and more of the produce. So, the milkman would now try to have more cows, would try to hire more people, he would try to hire more amount of goods in terms of capital goods. And so, the more demand for goods and services would also lead to more hiring of workers to meet the demand. Now, if you have more hiring it means less unemployment. So, more money in the economy led to more spending. More spending led to inflation, but it also led to less unemployment. So, more inflation means that more people have jobs. Now, a society always wants to have people who have jobs, and inflation is the price that the society needs to pay to have those jobs.

So, this principle of economics states that the society faces a short run tradeoff. Now, this is in the short run because in the long run, because of the actual prices - here we are only talking about the notional prices as we saw in the previous slide. But, the actual prices remain the same. So, in the long term things go back to the normal, but in the short run there is this tradeoff between inflation and unemployment. And this also leads to business cycles which is the fluctuations in the economic activity, such as employment and production. So, in the short run, when the government prints more money, there is inflation which leads to more employment. And, this employment also leads to more production. But, then because of inflation after a while people are negatively impacted. And so, the government then shrinks the money back, it shrinks the economy and with that the level of inflation comes down, but together with that the employment and production also come down. So, this is a short run tradeoff that the societal always faces.

If we were to plot a curve between the rate of inflation and the unemployment, we would get the Phillips curve. The Phillips curve shows that if you have higher inflation, you have lesser amount of unemployment. If you have lower inflation, you have more amount of unemployment. So, this is a choice that needs to be made at all times.

So, these are the 10 principles of economics that we saw here. We will revert back to these principles again and again in this course and we will also try to understand: what is the impact of these principles on conservation of natural resources?

So, that is all for today. Thank you for your attention. Jai Hind!

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Module 2
What is Conservation?
Lecture 1
Conservation in the Anthropocene

Namaste! Today we begin our new module: What is conservation? This module will have 3 lectures, Conservation in the Anthropocene, human population growth and food requirements, and unsustainable development. Let us begin with conservation in the anthropocene.

We have seen before what conservation is. Conservation comes from the two Latin word roots con which means together and servare which means to keep. So, literally conservation means to keep something together. What is this something? Conservation in the context of wildlife and in the context of natural resources means the preservation, protection and restoration of the natural environment and wildlife.

So, we are trying to do preservation, protection and restoration. There are three components of conservation: preservation, protection and restoration and we do the conservation of natural environment or natural resources and wildlife. Now, when we say conservation in the anthropocene, what is anthropocene?

Anthropocene is a proposed epoch. What is an epoch? An epoch is a time period in the history of Earth.

So, conservation is a proposed epoch which dates from the commencement of significant human impact. It begins from the beginning of significant human impact on Earth's geology and ecosystems including, but not limited to anthropogenic climate change.

So, it is a time period and this time period begins from the beginning of significant human impact on earths geology and on the Earth's ecosystems and it includes, but it is not limited to anthropogenic - which means manmade - manmade climate change. So, it includes manmade climate change it includes global warming, but it also includes a number of other things.

Now, what are those other things the first such impact is over consumption. Consumption by itself is not bad, but over consumption is striking. What is over consumption? Most of the natural

ecosystems and most of the natural systems have a rate of growth. So, if you consider a forest the trees in the forest are growing; you also have the next generation that is coming from the seeds. Similarly if you consider the oceans or any other water body you will have fishes and these fishes also have a natural rate of population growth.

Now, if humans remove this population at a rate, which is less than the rate of population growth, in that case the population of these trees or these fishes will either remain constant or they will go on increasing with time. But over consumption states that if you remove these organisms at a rate that is greater than the rate of the population growth - in that case the population will start to decline and that is known as over consumption.

So, one human impact on the environment is over consumption and these days we are over consuming literally everything. We are over consuming the fishes because of which the stocks of fishes in most of our oceans are going down. We are over consuming forests because of which we have seen massive deforestation. We are over consuming water resources because of which a number of water bodies are diminishing. We are over consuming the soil resources because of which there is a heavy amount of soil erosion and quite a lot of land is turning barren. We are over consuming most of the resources. So, over consumption is one major human impact on the environment.

Another one is habitat destruction. Habitat as we have seen is the natural home or the abode of an organism. If we damage that habitat - if we destroy that habitat - and why will we destroy any habitat - because of over consumption.

So, there is an animal that lives in the forest - let us consider elephants. Elephants live in the forest. Humans want to have access to wood and if humans take off most of the wood and if they convert these forests into a barren land, in that case the habitat of the elephant will be destroyed. So, habitat destruction is also a major human impact on the environment.

Another one is desertification. In desertification we are over consuming the water resources at such a rate that we are turning lands into deserts. A major factor in desertification is also overgrazing. Through overgrazing the cover of vegetation from the land is removed and when once this cover is removed the Sun's rays are able to heat up the land very quickly and dry up the land. So, excess removal of water as well as over grazing are leading to desertification.

Also we have ocean acidification. Ocean acidification means that we are converting the pH of oceans towards acidity which means we are reducing the pH of the ocean bodies. How are we doing that? A major factor is the release of carbon dioxide. When we are burning fossil fuels, when we are cutting down trees we are doing two things. One is that we are releasing carbon that was stored in the fossil fuels for a very long period of time - out into the atmosphere. When we are burning coal, when we are burning petrol, diesel, natural gas - we are releasing the carbon

that was stored inside the Earth into the Earth's atmosphere. And at the same time the second thing that we are doing is that we are removing those things that were removing carbon dioxide from the atmosphere. Plants remove a major chunk of carbon dioxide through the process of photosynthesis, but then out of our greed for land we are also destroying the forests.

So, on the one hand we are increasing the amount of carbon dioxide that is being released into the air and on the other hand we are also reducing the sinks of carbon dioxide. What happens when both of these things happen together? The level of carbon dioxide in the air starts to grow and when you have too much of carbon dioxide in the air it has to go somewhere. And carbon dioxide can dissolve in water. So, some part of this carbon dioxide also dissolves in the ocean waters. And when carbon dioxide meets with water it forms carbonic acid. And when you have an acid that is growing in concentration in the oceans the pH level of the ocean drops and this is known as ocean acidification.

And this is a very major impact on a number of ecosystems because quite a number of organisms that live in the oceans have calcareous shells made of calcium and calcium compounds say calcium carbonate. If you make the oceans into an acidic body what happens is that this calcium carbonate - it reacts with the acid and it dissolves - it converts into a bicarbonate and it dissolves in water. And so quite a lot of ocean reefs are getting affected. At the same time when the acidity of water - when the pH of water turns acidic this water is now no more capable of supporting a large number or a large variety of organisms - because every organism has a level of tolerance for a number of things. Not all organisms can survive in acidic waters.

So, when you turn the water acidic those organisms that are not able to tolerate acid waters - they will die off. So, ocean acidification is also a major human impact on the environment.

Next we have ozone depletion and a major cause of ozone depletion is the use of chemicals that are known as chlorofluorocarbons. These chlorofluorocarbons have been used for quite some time as refrigerants and also as propellants. Even in the case of a number of shaving foams we have been using chlorofluorocarbons as the agent that propels the foam outside from the can. Now these chlorofluorocarbons - they react with the ozone that is there in the stratosphere - and they deplete the ozone layer. Now once that happens - ozone is something that protects all life on Earth from the UV rays of the Sun - from the ultraviolet rays of the Sun. So, if the ozone layer thins or when it collapses, what happens is that more and more of UV rays from the Sun are able to reach to the Earth. And these UV rays can have negative impacts on a number of organisms. For instance they can lead to skin burns. They can even lead to some forms of cancers. They can increase the amount of or the rate of formation of cataracts in the eyes of different organisms. So, ozone depletion is another big human impact that we are seeing in anthropocene.

Now remember that most of these things did not occur before the impacts of humans was felt - because things like chlorofluorocarbons - they do not occur naturally on the Earth. This is a

completely manmade chemical and we have produced this chemical at such a vast scale that it has led to ozone depletion.

Next we have changes in the bio geochemical cycles such as nitrogen cycle. Bio geochemical cycles are the cycles through which nutrients move through the biological realm of the Earth which is the biosphere meaning all the plants and animals, it moves through the geological realm of the Earth which means that it is moving through the soil. So, this is a cycle through which the chemical nutrients are moving through the biological and the geological realms of the Earth. Common examples are things like carbon cycle or nitrogen cycle or phosphorus cycle or water cycling.

Now when we consider nitrogen cycle - nitrogen is a nutrient that is required for the growth of plants. It is also required for the growth of animals. Now, plants get nitrogen in the form of nitrites and nitrates from the soil. And how do these nitrites and nitrates form? Because we have nitrogen in the air - as much as 78 percent of the air is nitrogen - and when this nitrogen reacts with oxygen during lightning it converts into a nitrite or a nitrate and with rainfall it comes down to the Earth. Similarly, we have some organisms which are known as nitrogen fixing organisms. Common examples are Rhizobium, which is a bacterium, which lives in the ah root nodules of leguminous plants. Also other organisms like Nostoc and Anabaena also perform some amount of nitrogen fixation. So, these were two major routes - two major natural routes through which nitrogen from the air was converted into nitrites and nitrates and made available to the plants.

Now, what humans did was through the use of chemical cycles such as Haber process or Ostwald process, we are artificially converting the nitrogen in the air into nitrites and nitrates and using them as fertilisers - which is fine to some extent, but then an overuse of these fertilisers is also having a negative impact. Why? Because these chemical fertilisers affect the chemical structure of the soil; they affect the organisms that live in the soil. And when they are used in an excess amount quite a lot of these fertilisers also get washed down to areas where we do not want them. So, if these nitrogenous fertilisers - when they get washed down into a water body - then it essentially pollutes the water body because we did not make these nitrogenous fertilisers to be dumped into the water bodies.

Now, when these nitrogenous fertilisers are made available in the water bodies they have certain impacts. They will lead to a very rapid growth of plant material in the water bodies as well. And what will that lead to? If you have a water body - suppose you have a pond and there is a very heavy growth of algae - what will happen? The algae is taking up space in the water body. So, less and less of space is now left available for the other organisms such as fishes. A number of these water plants can also entangle the animals that are that normally live in the water bodies. And when we have a very rapid and profuse growth of these plants - after a while these plants will also die. And when they die - so much amount of organic carbon is there in the water body that needs to be degraded. And when the degradation of these plant bodies occurs it also takes up

the oxygen that was there in the water. And once that happens the level of oxygen in the water body goes down because of which a number of organisms are going to die. So this is a major impact. We call it as eutrophication of the water body which is the adding up of nutrients into the water body and this has very drastic and dramatic effects on the water body.

So, changes in the biogeochemical cycle such as nitrogen cycle through the use of mostly fertilisers is also a major human impact that was not present before the anthropocene - because earlier we did not have these chemical processes - Haber process or Ostwald process. And so the nitrogen that was brought to the Earth was brought in a very small quantity as compared to what we are putting into our soil and into our water bodies in the anthropogenic age.

Loss of biodiversity and extinctions because of a number of these factors and also because of the rampant poaching that humans do. There is a big loss of biodiversity: we are seeing a large wave of extinctions of organisms. Changes in the distribution of organisms, changes in biodiversity - why do we see changes in the distribution of organisms? Because of the changes that we are making to the surface of Earth. So, for instance if there is an organism that requires a water body and if humans come and they over consume the water that is there with the water body - this water body will dry off. Once that happens the organisms that lived in that particular place will either have to move to some other place if they are able to. Suppose they are flying animals or they are animals that can do locomotion on the ground - they will shift to some other places. But a number of other organisms will just perish. And so there will be a change in the localisation of biodiversity because in this area earlier we had say hundred species and now we do not have those species - probably we have some new species that have come up into this area. These are changes in the distribution of organisms - changes in biodiversity.

Then we have climate change. And a major causal factor of climate change is the release of greenhouse gases especially carbon dioxide. Now carbon dioxide - when it is there in the atmosphere - it acts as a greenhouse gas which means that it traps the heat of the Sun in the atmosphere. So, what it does is that it permits the short wavelength portion of the electromagnetic radiation - especially the infrared rays to come inside, but then when they are released back as long wave radiations - it traps them and slowly and steadily the temperature of the Earth increases. Now, once the temperature increases - it also has a number of other impacts because our winds or water currents are all related to the differences in temperatures that are there in different regions of the Earth.

If you increase these temperatures - if you take it with the natural distribution of temperature on the Earth - what happens is that the wind patterns change, the climatic patterns change. So, we might see things such as excessive drought or excessive rainfall that leads to floods or very high increase in temperatures which may lead to things like heat stroke or very drastic climate change events such as cyclones. All of these increase in their intensity - the increase in their duration and the increase in their probabilities. This is climate change. We also have non manmade climate

change, but the level of climate change that is being brought about by human activities these days is so high that it has overwhelmed the natural levels of climate change. So, this is another major human impact on the environment.

Other impacts include soil erosion changes in geomorphology, deposits derived from concrete lime mortar or other calcareous materials outside the cave environment. So, changes in soil erosion, changes in geomorphology are also major human impacts on the environment.

Then we have changes in stratigraphy due to increased sediment load and deposition because of deforestation, construction activities and so on. Now, changes in stratigraphy - it means that there is change in the levels or the layers of soil that are naturally present. And why do we see these changes? We are observing these changes because of a huge amount of sediments that are being brought - through mostly the river systems and the water systems - into the lakes. So, earlier suppose we had every year - we had 1 millimetre layer of soil that was coming naturally, but then because of deforestation and because of agricultural activities and other activities now we are seeing not 1 millimetre, but say 10 millimetres of soil that are coming. This is leading to changes in stratigraphy.

Then changes in the elements in the atmosphere: C 12 or carbon 12, that is released from fossil fuels; radionuclides that are released from nuclear fallout and atomic reactors. We are not just seeing changes in the amounts of elements that are there in the atmosphere, we are also seeing a change in the radioactive levels of different elements that are there on the planet Earth.

Now, changes in C-12 concentration - why does that happen? Because the fossil fuels that we are using were made from carbon that has been stored for many years - many thousands of years or many millions of years. Now, in that long period most of the radioactive carbon which is carbon 14 has disintegrated and has converted into other nuclides. So, the amount of radioactivity that you will have in the carbon that was stored for a very long period of time will be much lesser than the amount of radioactivity that we see in the current carbon - because carbon fourteen is regularly being produced in the atmosphere. Now, if we release a large amount of carbon twelve - because we are burning the fossil fuels - that is changing the carbon twelve carbon fourteen ratio that was there in the atmosphere. Now this will not have a very drastic impact on most of the organisms, but yes this is a change that is brought about by human beings on their atmosphere. So, this is another indication of the beginning of anthropocene. When we start seeing changes in the radioactive ratios in different gases or in different elements - that would give us an indication of when anthropocene begins. And similarly we are seeing radionuclides that are released from nuclear fallout and atomic reactors and a number of these radionuclides just did not exist before humans brought them on Earth.

Then we are seeing changes in soil - because of water logging, desertification, buildup of pesticides and other chemicals, and a lot of this has to do with agriculture. Because of

agriculture, when we are storing water in certain areas, when we are constructing canals - it is leading to water logging in certain areas. Also when we are doing excessive irrigation for water thirsty crops - and if the soil is unable to tolerate that much amount of water, then it might lead to water logging.

Then we are seeing desertification in those areas where we are excessively taking out water and we are also letting animals perform overgrazing. That is leading to the soil turning into desert soil. Then there is buildup of pesticides and other chemicals that are being sprayed especially for agriculture, but also because of those chemicals that are being released due to industrial activities. That is leading to major changes in the soil.

Introductions and invasive species: what humans have done is that they have been a medium of bringing different species from one part of the Earth to another part of the Earth. Now, some of these introductions are done voluntarily. So, for instance a species such as lantana was brought from Africa into India because there were some humans who thought that this is a beautiful looking plant and we should have them in the hedges, we should have them in the gardens here. And so this plant - Lantana camara, it was brought from Africa into India and when it came to India it became an invasive species - because the other species in Africa were able to tolerate this species - they were able to keep this species in check, but our species were did not evolve with this species - Lantana camara; they did not know how to deal with this species. So, what happened was that in a very short period of time this lantana entered into our forest and slowly and steadily it replaced the native species in a number of areas and it became the predominant species. Now this is an introduction of a species that was done through volition because humans wanted to bring this species from one place to another place. But then we also have a number of involuntary species introductions especially because when humans move from one place to another place a number of organisms are also able to hitchhike on the aircrafts, on the ships and they are able to come from one place to another place. Similarly, major introductions also happen in the form of food articles. So, for instance if there is a person who is going from say Africa to Australia and is taking certain food items - say certain fruits with him or her into Australia. So, what is happening is that the seeds of these fruits are also coming this with this person into Australia and when these seeds reach into this place then it is possible that this species of plant gets introduced into Australia. Now, nobody wanted to introduce this species into Australia, but then involuntarily because humans are moving from one place to another place and they are taking things with them - then it is leading to the introduction of species. Another good example is the movement of a number of organisms through ballast water. Now this is something that we will see later on in a lecture, but in short what happens is when you have a ship that is moving from one place to another place, for maintaining the stability of the ship, whenever the luggage in the ship is removed - whenever the cargo is removed, some water from the ocean or the water body where the ship is residing is pumped inside the ship so that it maintains its level - it does not rise and sink with the load. It has to be maintained at a constant level. So, whenever you are putting the load inside this water will be pumped out - the same

amount of weight as that of the cargo that you are putting in - and when the cargo is removed water is pumped inside.

Now what happens is that when you are pumping this water inside the organisms that are living in this water also are able to enter into this ship in the form of the ballast water and when the ship moves to another area and when this water is pumped out the organisms that were there in this ballast water are now released to the new environment. Now, it is possible that if these ships were not moving or if these ships were not using the ballast water it is quite possible that these organisms would have never moved from one place to another place. But then because of these ships that are using the ballast water, we are now seeing introductions of a number of organisms across continents and a number of these organisms are also invasive species which means that they grow at a very fast pace. And they also are able to overwhelm the natural species that are present in the new location - and in a short while we will observe that they have overwhelmed the local populations - they have led to a rapid decline or a collapse of the indigenous species - and they have established themselves. So, this is also a major impact of humans on the environment.

Then we have pollution including light pollution that we are seeing because of the humans. We are observing coral bleaching. Now coral bleaching - it means that because of changes in the water of the oceans especially because of acidification and because of pollution a number of corals die off - and when they die off the colour of the coral changes - it becomes white in colour. It becomes bleached. Bleaching is an indication of the death of corals. Now corals are those species or coral reefs are those formations that support a number of other species - because fishes can lay their eggs inside these corals, a number of other organisms can find their safety inside these corals. So, corals are very important formations for biodiversity and when coral bleaching occurs we also observe a rapid and a massive decline in biodiversity in those areas. Coral bleaching is also another human impact on the environment.

One more impact is wars. And wars are not just tragic from the human point of view, but they are also tragic from the environmental point of view because they release massive amounts of noxious substances into the environment which leads to a massive decline in biodiversity. So, these are some human impacts on the environment that we are observing in this epoch called anthropocene.

Traditionally we take the beginning of anthropocene as the day on which we had the Trinity explosion in 1945. So, this is the beginning of the nuclear age and this date is taken as the beginning of anthropocene.

Now, over time humans have become more and more conscious of the the impacts that they are having. And so, these days we also see - especially in the 1960s we started talking about things such as The Population Bomb. We started to realise that our populations are growing at such fast

paces that it is now becoming impossible for nature to tolerate us. And so we started talking about the population bomb - that if we do not control our populations in a very short period of time we will over consume so much of resources that we will have nothing left. We started talking about - are there certain limits to growth? We all want to have growth - we all want to have development, but is there a limit to growth? Because if we have a large population and because of development we are providing them with so much amount of resources that - if we have a large population with a large amount of affluence because of development it will lead to an overconsumption of a number of resources. So, is there a limit to the growth? Is there a limit to the development? We started talking about these things.

And we started talking about how do we quantify the impacts that humans are having on the environment. And we came up with this formula:

I is equal to P into A into T.

I here is the impact of human activity on the environment. P is the population in the area and this area could be as large as the whole world.

So, what this formula is saying is that if the population increases the impact of humans also increases. So, I is directly proportional to P. I is also proportional to the affluence. Now affluence is the average consumption of each person in the population. So, affluence is telling us how much amount of resources are being consumed by one person. Affluence is generally measured through values of GDP per capita.

And what affluence is telling us - is that if you have more amount of resources - you are over consuming the resources - the more affluent you are the more amount of resources you are using. And so the amount of impact that you will have by using a large amount of resources will also be large.

So, I is also proportional to A. And I is also proportional to the technological advancement or a measure of how resource intensive the production of affluence is. So, I is equal to P into A into T. If you increase the population you will have more impact, if every person in the population starts to use more amount of resources you will have more impact, and with a more - better technology you will be able to provide these resources to the people. Or this technology may also be at times used to overcome the impact.

But in most of the cases what we have seen so far is that with more and more technology we are also increasing the impact - because of the need for more and more materials and because of an enhanced efficiency of the processing of these resources. So, I is equal to P into A into T. Now, let us now observe how P and A and T have been changing through time.

If you look at the world population we find that the world population for a very long period was nearly constant. Then it started to increase and then roughly around the time of Industrial Revolution, we see that it has started to rise very quickly. So, this is now the exponential growth of population and now it is going at a very fast rate. And in the next few years it will reach somewhere near 10 billion - currently we are around 7 billion.

So, the world population has been increasing very fast. So, the P component of I is equal to P into A into T has been increasing and the rate of increase has also been increasing. So, it is now an exponential increase in population. If you look at the density of populations there are a number of areas, where the human population density is very large. In those areas where we have a large human population we have seen that the impact of humans will be large and so these are the areas where also the impacts of humans will be large. Now if you consider our country - our country is one of the more densely populated areas of the world and because we have a large human density - because we have a large human population we need a lot more resources to feed these people. So, essentially the amount of agricultural expansion has been increasing with time. Now with the need for more agriculture we need more land because of which we are cutting up more and more of the forest. We want to provide affluence to all these people because of which we require more and more resources because of which again we are cutting down a number of forests and we are using those areas for things like mining.

So, any area that will have more population will also have more impact and what we are observing here is that not only the population has been increasing with time and the rate has been increasing with time, but also there are certain locations on Earth where the population density is very high and that has an impact on the total human impact on the environment. The population densities have also been growing over time in a number of areas.

Now, let us have a look at affluence. Affluence can be measured by how much amount of resources are made available to each and every person to consume. If a society is able to produce more resources those resources are available for people to consume. So, we can have an indication of the amount of affluence through a measurement of the amount of industrial productivity.

We can observe here that the productivity of a number of items has been increasing and we can see that around 1600 or 1650 AD we see a rapid change. Before that this curve was roughly horizontal and after this it has been rising exponentially. So, this can be an indication of where we started to have more impact on the environment.

Affluence can also be measured in terms of money that people have and if you look at world GDP over the last 2 millennia we see that here again we are seeing an exponential growth. Roughly after around 15 - 16 hundred AD we start seeing an exponential growth. So the affluence has also been increasing with time.

When we say I is equal to P into A into T the P component has been increasing the A component has also been increasing.

Now, if we wanted to know how much is the impact of people in different areas we can look at GDP per capita in different countries of the world. And here we will observe that the areas such as the United States or the UAE - they have - or most of the western Europe or Canada - they have a very high GDP per capita which means that the affluence in these areas is large.

And the GDP per capita has also been increasing with time, and this rate of increase has also been increasing with time. What that means is that not only is the affluence increasing, but the rate of increase has also been increasing - which means that in a very short period of time we will reach very unsustainable levels of affluence. If nothing is done to stop the impact then probably it will lead to drastic consequences.

Now, let us observe what is happening in terms of GDP per capita if we consider two different time periods. So, in this curve the GDP per capita in 1960 is represented on the x axis and the GDP per capita in 2014 is represented on the y axis. Suppose the rate of growth was the same everywhere. So, that would have led to countries that would have been on this line - this line at 45 degrees is showing that if you had say 500 GDP per capita in 1960, you also have 500 GDP per capita in 2014 - which means that there is no change in the GDP per capita - there is no change in the affluence.

Now, what we are observing with this curve or with this chart is that most of the countries are on the left side of this curve, which means that most of the countries have - or are observing increase in the GDP per capita. There are only a few countries in the world which are actually seeing a decrease in the GDP per capita, but in most of the countries the GDP per capita has been increasing by which you can say that the affluence level in most of the world has been increasing with time.

Now let us have a look at the T component - the amount of technology that is available to the society. Now we can use certain indicators to assess what is the rate of technological progress. We can look at Moore's law - Moore's law is an indication of the number of transistors that are there in a microprocessor and it says that the number of transistors in a dense integrated circuit doubles approximately every 2 years. So, what Moore's law is saying is that if you look at an integrated circuit the number of transistors will double every 2 years. Now this was an observation that we had earlier in the 1960s. What is the position at present?

Well we are observing that actually the number of transistors has been roughly doubling every 2 years and we are observing an exponential increase, which is an indication that we are seeing a technological progress that is also increasing exponentially, which means that the T component

of the equation $I = P \cdot A \cdot T$ has also been increasing and the rate of increase has also been increased.

Other indicators include things such as the super computing power that we have. So, if we make a plot of the super computing power in terms of FLOPS, we will find that here again we see a roughly exponential increase. Increases in the microprocessor clock speed - this is another indication of technology. Here also we are observing an exponential increase in the microprocessor clock speed with time. So, T has been increasing and this rate of increase has also been increasing with time.

The sequencing cost per DNA - the number of human genome base pairs that are sequenced per US dollar - that is also increasing - which means that for every dollar we can now sequence more and more amount of the genome which is a good indication of the technological progress.

So, what we are observing here is that in the equation $I = P \cdot A \cdot T$, P is increasing, A is increasing, and T is increasing - and all three of these are increasing exponentially - which means that the impact has also been increasing at a very fast pace.

Now, if you look at the impact of humans, we can divide the human history into 3 different stages. In the early society - in the aboriginal society we had small P , small A , and small T - small population, less amount of affluence, less technology. Because there was a small population, so, there were less number of mouths to feed. There was a less requirement of resources because the affluence was low. People just did not feel a need to have more resources - they just did not know about having resources such as air conditioners or computers. The affluence was very less and the technology was also missing. So, in those days even if there were some people who wanted to have more and more resources, the technology was not present to enable them to extract these resources from the environment. So, the P was less, A was less, and T was less and so, there was a little impact on resources - and the resources were in plenty.

There was a little need - there was hardly any need to conserve the resources - though in certain societies certain fruit or food or fodder trees may have been conserved as religious trees. So, what was the thinking of humans in those times? The thinking was that nature - or mother nature is providing us everything in plenty. And there is nothing that we need to do to conserve because our requirements are so less - and the amount of resources that there is available - it is so large in comparison that even if we do all the exploitation that we can, that is not going to have any impact.

So, in the aboriginal societies we see that there was hardly any talk of conservation although a few trees such as the fruit trees or the fodder trees - they were revered as religious trees and so they were conserved. We had a feeling - a very small feeling of conservation that was mostly religious - that had little to do with the amount of impacts that we have on the ecosystem. That

is the first stage of development of the society.

Then we moved to stage number 2. In stage 2 we started seeing modernisation of the society. With modernisation of society - it actually began with technological improvements - if you have better technology you can have more resources. If you have more resources you can increase the affluence of people and if you have more and more people who are more and more affluent, they are protected from diseases, they are having a large lifespan or their lifespans are increasing and at the same time they do not have to work so hard because technology is there to help them out. In such a situation the population will also start to rise. So, with the beginning of modernisation we start seeing a growth in population, a growth in affluence, and a growth in technology - and so there is a growing impact on the resources due to unabated exploitation and resources are now getting scarce with time.

So, with the development of modernisation we actually started feeling a crunch - that yes our population is growing fast, it is growing more and more affluent and we are getting more and more technology, but then now there is a dearth of resources. For instance we had means to convert iron ore into iron, but then now we were seeing that the iron ore that was available in the surroundings that has now become exploited. And so now we require more sources of iron ore - because we have technology to convert it into iron and we have a population that has been increasing and this population wants this iron. Similarly with affluence there was a need for a number of new items. People wanted to build fancier homes. So, they wanted more amount of wood, but then the local forests are now empty because we have a better technology to cut these forests and we cut these forests. And so now, these forests are gone, but then there is an increase in population and with increasing affluence they also want more and more of wood. What do we do?

So, modernisation was also a time of expansion. There was an increase in need to conserve the resources, but then this need was not a very hard pressed need - because for the time being the need for resources could easily be met through expansion of the empire. So, we start seeing the expansion of empires such as the Roman Empire or the British Empire and in a number of these situations what these empires did was to make other areas their colonies - which meant that the people in these empires had now access to resources in other areas as well. So, there was little need to conserve the resources and there was a possibility to get these resources from other areas and this was done through an expansion in the empires and through the development of colonies.

But then we moved into the third stage - which is the modern society. Now, in the modern society the population is large because it has been increasing with time, the affluence is large, the technology is large, but then all the areas that could have been brought into the hold of the empire - they have already been brought into the hold of the empire. Now we do not have any more land to bring to the empire. What do we do now?

So, there is a large impact of resources - because of unabated exploitation the resources are extremely scarce, but then there is no more land to bring into the fold - there is no more land to exploit and so, now the resource conservation has become extremely imminent - because we do not have any other option - we do not have the option of bringing in other lands to get these resources.

And so the only option that is left is to conserve what we already have. And so scientific management of resources gets born as a discipline to meet the needs of the society. The modern society is now putting a lot of emphasis on conservation and on sustainable use of resources.

But then we to make use of these resources in a sustainable manner we not only require this feeling or this devotion to conservation, but we also require means to perform these operations. So, we need not just a willingness, but also the technology and also the economic inputs that will make this possible. Most of the world from the mid nineteenth century is now in this stage. So, conservation has become a very important part of life these days.

Now, not everything is going that bad because we can also see a number of silver linings. There is a more and more - greater - emphasis on recycling of resources, recycling of things like plastics. If we see the percentage of plastic that was recycled in the nineteen eighties - there was hardly any. But today we can see that almost twenty percent of the plastics is getting recycled. Now of course, the amount of production has also gone up. So, if we look at the amount of waste that we were generating in the 1980s that was nothing compared to the amount of waste that we are generating now. But at least now there is an emphasis to recycle things - there is an emphasis that we should not dump these plastics out into the atmosphere - or out into the environment - out into the water bodies. We should not just go and burn them off to release noxious fumes into the environment. There is a much greater emphasis on recycling things and on disposing these waste items in a more prudent manner.

Another silver lining is that the rate of population growth has already peaked. We are now in a stage where the rate of population growth is decreasing with time. Now even though our populations have been increasing, but the rate of increase has now gone down and the rate of increase is now going down very quickly. In a short period of time we might even move to a stage of a stable population. If we look at the population growth we can see that this is an S-shaped curve. And in this S-shaped curve we are currently in the middle. We can now project that the world population will stabilise at around 10 or 11 billion people.

The rate of population growth is determined by the slope of this curve. The slope of this curve was very high in this region and it goes on decreasing when we reach here. So, the slope is less and we are right now in the middle. We have already crossed the peak population growth rate and the growth rate of population is now going down - which is a good news.

Another thing is that we are observing reducing fertility rates in a large number of countries. The fertility rate - or the number of children that a woman would have on an average - that is also going down. Your parents or your grandparents had many more siblings and we are also observing changes in the population pyramid. So, in the 1950s we had a population pyramid that had a much greater base as compared to the top, but now we are shifting to a population pyramid that does not taper. This is also an indication that the rate of population growth has been decreasing - and it will further continue to decrease when these children reach their adulthood. We are also observing demographic transitions in most of the areas of the Earth.

Now, what is a demographic transition? A demographic transition tells the story of a society in terms of different stages. In the first stage we have a society in which we have a high birth rate and a high death rate. Now because you have a high birth rate every woman or most of the women on an average have a large number of babies and most of these babies also die off very soon - because there is a high death rate. And this death not just happens in the time of childhood - it also continues into the adulthood.

Now, why do we have a society like this? Because we do not have advancements in medical care. So, there is no way to fight diseases and a number of people die out of diseases. Now because the death rates are high, if the society has to continue, it should maintain a high birth rate as well. So, this is the first stage in which you have a high birth rate and a high death rate.

Now, with advancement of technology people start working on ways to reduce the death rate - and the ways to reduce these death rates are medical advancements. So, we come up with ways of treating diseases - we come up with antibiotics, we come up with antiseptics and so on. And slowly and steadily we are able to bring the death rates down. But then we have not done anything for reducing the birth rate.

So in this state we have a society that has a decreasing death rate, but still continues to maintain a high birth rate. So, more number of babies are born and less number of people are dying. In that stage we will start seeing an increase in the population. So, the total population will start to increase. In the first stage the high death rate and high birth rate were able to counter each other and the total population growth was less - which is what we saw for most of the presence of humans in the human history. But then starting from say around 1500 AD we start seeing a large increase in population - because we have now started to bring the death rates down now. With this exponentially increasing population people then start feeling that yes - this population is growing so fast that in a short period of time it will overwhelm the resources that we have - and so, now the society starts to look at ways to reduce the birth rates as well. And how does society reduce the birth rate? Well it comes up with things like contraceptives, it comes up with education - and with more and more people going out to work and being productively employed, there is a less and less incentive for people to have more and more number of babies. Why? Because in earlier times every couple used to think that ok, if I have more number of

babies, I have more hands that are going to help me out in the fields - that are going to help me out in my profession. But now with the increase in technology we have things like tractors available for us. So, even if a farmer has a single child he or she might be able to perform all the duties of the field without the need for any more hands - because we now have access to machines. Similarly in the earlier times people used to think that because of the high death rate it is possible that a number of my children are going to die off, but now everybody knows that yes we have such good medical facilities that most of my babies are going to survive and so, people make this conscious decision that we should have less number of babies. And so, in this third stage the birth rate also starts to fall. Now in this case the death rate is still falling - because we are still working on medical advancements. But now the birth rate has also started to fall and so, the population growth will now turn towards a plateau. And in the fourth stage we have a low birth rate and a low death rate. And so, the population now stabilises. There is no further increase or decrease in the population and the population stabilises.

So, this is a demographic transition that we have observed in a number of societies - and the silver lining is that with the increase in technological progress we are observing this demographic transition in more and more areas - we are observing that we have brought down the death rates and we are also bringing down the birth rates.

So, anthropocene is an epoch in which humans have put a very huge amount of impact on the ecosystems - a very huge amount of impact on the geology. But then the silver lining is that we are now shifting towards reducing these impacts.

That is all for today. Thank you for your attention. Jai Hind!

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Module 2
What is Conservation?
Lecture 2
Human population growth and food requirements

Namaste! In the last lecture, we were looking at conservation in the anthropocene and we came across with this formula:

$$\mathbf{I} = \mathbf{P} \times \mathbf{A} \times \mathbf{T}$$

So, the impact of humans on the environment is equal to their population which is shown here in P, the level of affluence of the society which refers to the amount of resources that each person on an average requires or uses, and the level of technology, that is there in the society.

Now, of late what we have observed is that the level of affluence does not increase very fast - it takes its own time. And the level of technology is somewhat also dependent on the population that we have because more the number of people that are there in a society the greater is the chance that somebody would come up with a new technology. So, essentially the level of population of humans has the highest bearing on the impact. In this lecture, we will explore what causes the growth of human population, how we can model it, and how we can also model the food requirements of humans.

One of the earliest thinkers to think about the issue of human population growth was Thomas Robert Malthus. He was an English cleric and scholar who lived in the 18th and 19th centuries. And in 1798, he published this book, An Essay on the Principle of Population, and this is considered as one of the most seminal works on human population growth. Till this date, it has influenced studies in population ecology.

So, what did Malthus have to say about the growth of human population? He observed that population grows in geometric progression, roughly doubling every 25 years. The human population grows in geometric progression. Now, what is geometric progression? Geometric progression means that every term in the sequence is a multiple of the previous term. That is we can write it as the nth factor or let us write it as

$$a[n] = a[n - 1] \times k$$

That is if you take a ratio of the nth factor of the series and the n minus 1th factor you will get a constant k. And in this case Malthus saw that the population was doubling. So, the factor k here is 2, because 2 divided by 1 is 2, 4 divided by 2 is 2, 8 divided by 4 is 2, and so on.

So, every factor in this every term in the series is the previous term multiplied by this constant k which is 2. 1 into 2 is 2, 2 into 2 is 4, 4 into 2 is 8, 8 into 2 is 16 and so on. So, the population grows in geometric progression. Now, how much time does it take for this population to move from 1 to 2? And for this Malthus said that it roughly doubles in every 25 years. So, in 25 years the population doubles.

On the other hand, he observed that the food supply increases in arithmetic progression. So, in this year suppose you have 10000 tons of food, in the next 25 years you will only increase it to 20000 tons, in the next 25 years you will increase it to 30000 tons, in the next 25 years you will increase it to 40000 tons, and so on. This is an arithmetic progression.

In the case of an arithmetic progression, we say that the nth term of the series is equal to the n minus 1th term plus a constant k. So, if you subtract the n minus 1th term from the nth term you will get a constant which is k. And in this case what Malthus is observing is that this k is equal to 1. So, 1 plus 1 is 2, 2 plus 1 is 3, 3 plus 1 is 4, 4 plus 1 is 5, and so.

Now, in such a scenario in a very short period of time the population will increase to such an extent that it will overrun the food supply - which means that in a very short period of time there will be no longer sufficient food available for everybody. Now, in such a scenario what will happen? There will be an imbalance and it will be corrected by what he called as positive checks.

Positive checks include things such as vice, misery, famine, war, disease, pestilence, floods and other natural calamities. So, essentially what you mean by positive checks are those mechanisms that reduce the size of the human population by acting from outside or those mechanisms that reduce the human population, but these are those that we do not consider to be good mechanisms - such as misery or vice. So, he said that if the human population increased to a very large extent and there is a shortage of food there would be things such as famine. And in a famine there will be a big chunk of human population that will perish. Or there will be things such as diseases and in the diseases a big chunk of human population would perish. And he correlated these to the increase in the human population.

He said that this is not the only way out. There is also another option which is that the imbalance may also be corrected using preventive checks.

Now, what are preventive checks? Things such as foresight, late marriage, celibacy, moral

restraint, and so on. So, essentially the preventive checks that Malthus was proposing in his theory are the ones that do not kill anybody, but are able to reduce the size of the population through self control. Through things such as celibacy or late marriage, people are able to reduce the rate of population growth by having fewer number of children or by not having children. So, this is also an option that is available to the humans.

Essentially the Malthusian theory is more like a doomsday theory. He said that either you do these checks - either you try to reduce your own population or otherwise your - the human population will be brought down by nature by using so many of the positive checks such as famines or floods or diseases or pestilence or through certain moral checks such as vice or misery. For instance if the human population is too large and everybody is not getting sufficient food, people will turn into misers. People will develop vices, and because of which there will be a certain section who will try to hold the resources and others will die off. So, this is a sort of a doomsday theory that Malthus had proposed.

And to quite a large number of population ecologists, it did look like a very correct theory because if we plot the world population through time, we will find that it does follow some sort of an exponential curve which is a geometric progression. So, for every population it is doubling in certain periods of time. Now that period of time has not come exactly to be 25, but more or less the more people that are there in the world, the faster is the population growth.

And we can represent it mathematically by saying that if $P[t]$ is the population at time t , then we can say that the rate of growth of population is proportional to P . So, the rate of growth is change in the population per unit time it is proportional to the population P and k is the factor that corresponds - that joins both of these. So, k in this case is a positive constant and upon integrating we can get that

$$P[t] = P[0] \times e^{(kt)}$$

where $P[0]$ is the population at time 0.

So, if you put t is equal to 0, e to the power of 0 becomes 1 and so, $P[t]$ becomes $P[0]$. So, $P[0]$ into e to the power kt . And with this we can also derive the doubling time. Doubling time is defined as the time that is required to double the population size. In Malthusian theory, we have seen that the doubling time is roughly 25 years - that we saw here - the population roughly doubles every 25 years. So, there is a doubling time in which the population is doubling.

And we can write that P at time t_d which is the doubling time is equal to twice the P at time 0. Now, putting these terms into this equation

$$P[t] = P[0] \times e^{kt}$$

we have

$$P[t] = P[td] = 2 \times P[0]$$

$$\text{So, } 2 \times P[0] = P[0] \times e^{kt}$$

Now, $P[0]$ and $P[0]$ get cancelled out, so

$$2 = e^{(k \times td)}$$

If we take natural logarithm of both the sides we will get

$$\log 2 = k \times td$$

$$\text{or } td = 1 / k \times \log 2$$

Now, if you remember this k is a positive constant. So, k here is a constant, $\log 2$ is a constant. So, it tells us that the doubling time is a fixed number. Similar to what Malthus also predicted. So, doubling time: Malthus had said that it is 25 years and in our equation also we are seeing that it is coming to be 1 by k which is a constant multiplied by $\log 2$ which is also a constant. So, we have a constant doubling time which is telling us that yes, the population doubles every fixed time and it is going through a geometric progression.

However, of late scientists have observed that this theory is not completely correct. Because it leaves out quite a large number of intricacies. It is a very simplistic model.

The first criticism is that the population growth is not as Malthus has suggested. So, if we look at the time that it has taken for the world population to double, earlier it was like 697 years for the world population to double from 0.25 billion to 0.5 billion. Then it came down to 594 years, then it came down to 260 years, and what we are observing is that nowhere is it touching this golden figure of 25 years.

So, according to Malthus the population was growing a bit too fast. In reality we are not seeing a very quick growth of population similar to what Malthus had predicted. And at the same time the doubling time is not fixed, the doubling time has been changing. So, it was as high as around 700 years, it was as low as 37 years, and currently it is close to 95 years. So, yes the population is increasing - there is a doubling, but this doubling time is not a constant. So, there are certain other factors that are also playing a role.

Then, if you look at the growth of agriculture, we will observe that even the rate of agricultural

growth is not what Malthus has suggested. Now, remember that Malthus had said that agriculture grows as arithmetic progression. So, from 1 it increases to 2, then 3, then 4. It does not move in a geometric progression - there is no exponential growth of agriculture and which was kind of true in the days of Malthus because in those days we did not have modern technology, there was hardly any crop breeding on the lines of genetics, there was hardly any artificial fertilisers or pesticides that were available. So, roughly the only way in which the agricultural production could go up was by bringing more and more lands into cultivation.

Now, if you - if any society tries to bring in more lands for cultivation there is another issue that starts to play. If we consider a town - here we have a town and in most of the cases the town was surrounded by the agricultural fields. So, what we are observing here is that here you have the place where people live and surrounding this is the place where you are having agriculture, and surrounding it even further you would be having things such as the forest.

Now, what this figure is suggesting is that suppose you wanted to increase agriculture, you wanted to increase these green areas further, so that they entered into the yellow areas - that is you are trying to convert more and more of the forest into the agricultural land. The problem that comes and that starts cropping up in a very short period of time is that if you put this portion into agriculture, it is at a much greater distance from the city or from the town that it is supposed to provide the food to. So, it becomes difficult to transport the food grains that would be produced in such areas that are far off from the towns or the cities and bring them to the towns and cities where there are the markets. Essentially what we have observed through centuries is that people put those lands under cultivation that are close to the towns or the villages and the far-off lands were kept as forest to provide for things such as wood.

Now, in the days of Malthus, when we did not have modern technology the only - probably the only way in which the agricultural production could go up was to bring more and more of these forests into forms of agriculture - which as we have seen was not very profitable. And so, the rate of agricultural production increase was very less. So, more or less it went on an arithmetic progression in the days of Malthus.

But now, if we look at the growth of agriculture, in any short period of time, we will see that yes, it actually grows in an arithmetic progression. So, here on the x axis we have the years, on the y axis we have the global cereal production, and it is increasing very slowly, and its not showing a nature of doubling. But then if we look at the long term changes in the yield of different cereals, we will find that yes, the curve looks very similar to the growth of human population. This is an exponential curve, this is showing a geometric progression on a large time scale. Now, why is that so? One major thing that has got to do with it is the level of technologies that we developed in the 19th and the 20th centuries.

So, from say this 1270 to somewhere around 1700 there is hardly any growth in agriculture, there

is hardly any change in the cereal yields. But then we started bringing in more and more technologies, we came up with fertilisers, we came up with pesticides, we came up with better storage facilities, and also we came up with more efficient manners of transportation and more efficient means of converting the forest lands into agricultural fields. And we are seeing the effect of all of these here.

So, from 1900, we have shifted from roughly 2 tons per hectare to around 8 tons per hectare - an increase of 4-fold in around a century. So, on a long term scale we can observe exponential increase in agricultural production as well - which is not what Malthus had said. Malthus said that there is only an arithmetic progression growth in case of agricultural production; we are observing a geometric progression on a long-term scale.

Third, Malthus did not incorporate the new land that becomes available with time. So, if you look at how the land throughout the world is being used for different purposes - what is the land use. This is a depiction of the current land use in terms of countries that if were completely put into that particular land use would represent roughly the land use situation in the world.

So, if you put the whole of North America and South America into livestock production - that is roughly the amount of land that we are using for livestock. 27 percent of the land in the world is being used for livestock production. Croplands are just 7 percent. So, if we take this East Asia we will get to the figure of roughly 7 percent of the world's area. As much as 26 percent of the world is covered with forest. Barren land is 19 percent, glaciers are 10 percent, all the built-up area including villages, towns and cities is just 1 percent. So, all the built-up area including all the infrastructure is just 1 percent. And 8 percent of the land is under shrubs and total amount of glaciers is just 10 percent.

Now, what is happening over the time is that more and more of forests are being converted into either livestock areas or into croplands. Similarly, more and more of this barren land is now being made available for crop production. Similarly, a lot of these shrub lands are now becoming available for crop production.

A very good example in this case is the Terai region of our country. Now, before the invention of DDT, the Terai region, which is the place where the Himalayas meet the northern plains was all full of marshes. And we had a very dense infestation of malaria in those areas. Now because of this dense infestation of mosquitoes and the prevalence of malaria all of this land was hardly put to any use. So, it was just left as forest - it was left as marshy land.

But with the invention of DDT nearly all of this land was brought into the fold of cultivation in our country. So, if you consider areas of Western Uttar Pradesh or Northern Uttar Pradesh - that is most of the - or a large portion of the sugarcane growing area of our country, specially in Uttar Pradesh and Uttarakhand - that is comprised of these Terai areas.

Similarly, a big chunk of our desert area was brought into the fold of cultivation through the Indira Gandhi canal. So, Indira Gandhi canal has brought in a big chunk of Rajasthan under the fold of cultivation. Now, these sorts of things were not possible in the days of Malthus. So, this is also another criticism of the Malthusian theory - that it does not incorporate the new land that has become available.

What is the quantum of this land? The share of land area that is used for agriculture in different countries is different. And we can observe that in certain countries such as India a big - a much bigger chunk of land is being used for agriculture as compared to say Canada. But if you consider the world - or most of the parts of the world, we would observe that there is an exponential increase in the total agricultural area in the long term, wherever we look at.

Even in areas such as Greenland or most of Africa or India or China, you name the country and in most of the countries the total agricultural area has been increasing - which tells us that roughly in every country we are bringing in those lands that were not used for agriculture, now into the fold of agriculture. In North America, most of the prairies which were grasslands were brought into - were brought under cultivation. In Africa, quite a lot - a large chunk of forests were cut and those areas were brought under cultivation. In Brazil - we will look at the case of Brazil in one of the lectures as well - a big chunk of forests were cut down to make way for ranches and to make way for cash crops. Similarly, in quite a lot of Southeast Asia, most of the palm oil production that is going on in the world today is happening in places that were earlier forests. So, this is something that Malthus had not considered in his time because these were roughly not possible in his time.

And in agriculture we see both an increase in the cropland area - the cropland area has also increased in an exponential fashion - and also the grazing area. And here we will observe that most of this increase was in the last 2 millennia. So, there is an exponential increase in the grazing area as well.

Another criticism of Malthusian theory is that it neglects the role of technology. So, Malthusian theory had said that agricultural production only increases in arithmetic progression. But then, if we look at the long term cereal yields in any country, we have seen that it has increased exponentially because of the technology. Similarly, if you look at the pesticide application per hectare of croplands, here again we will find that in quite a number of countries there is a very heavy use of pesticides in the cropland. Now, these pesticides were just not available in the days of Malthus. So, this is something that Malthus could not have foreseen. And if we look at the pesticide production or the imports in different countries we will find that they have been increasing with time.

If you consider different fertiliser applications all over the world, here again we will find a very

similar trend. Through time the consumption of fertilisers such as nitrogen fertilisers - they have been increasing. You name the continent, you name the area, and they have been increasing. They have been increasing in Asia, they have been increasing in America, they have been increasing in South America, and so on. In the case of Europe, there has been a slight decrease because in certain areas people are now shifting to organic cultivation. But more or less the trend is unequivocal - the trend has been increasing. If you look at other nutrients such as phosphorus - phosphorus application has also been increasing. The amount of water that the world has been using for agriculture - it also has been increasing. So, all the inputs of agriculture - they have been increasing with time. If you look at fertiliser use in kg per hectare of arable land in India, the United States and the rest of the world - it has been increasing.

And a lot of this increase has led to increased yields. So, if we plot say the application of fertiliser on the x-axis and the yield on the y-axis - and both of these axes are showing it in a logarithmic field - so, it is going from 1 to 10 to 100 to 1000 and so on - it is the logarithmic scale on the x-axis and it is the logarithmic scale on the y-axis - but then the evidence is clear - the more the amount of fertilisers that you apply to the croplands, more will be the agricultural productivity or the crop yield.

This increase in agricultural production was not possible in the days of Malthus - he did not foresee it. This is another criticism. Also, in those days the agricultural production could only have increased by bringing in more and more land under cultivation because the productivity was more or less constant. Now, with increasing productivity what we are observing is that less and less amount of land can give us the same quantity of food grains. So, by increasing the productivity, it is also possible that we might be able to leave certain forests as they are. So, if the human population is increasing and we need to provide them with more and more amount of food grains, there are two options. Option 1, bring more land under cultivation as was there in the days of Malthus. Option 2, use the same amount of land, but increase the productivity - which is what is the focus these days.

If you look at the global arable land or global crop production and if you plot it on the y axis and through time how much is the amount of land that is needed for maintaining the same production of crops - if we are plotting it we'll find that it has been coming down. So, after 50 years the world is using 68 percent less area or less land to produce the same amount of food. Productivity reduces the land requirement.

Other criticism that these days we are putting into the Malthusian theory is that the population is not related to food supply, but to total wealth. Population is not related to the food supply but to the total wealth. What we mean by that is if you consider a society - as the wealth increases we start observing demographic transition. Now, what is demographic transition? We had seen it in the last lecture as well. In the early societies, we have a situation where the death rate is very high. Now, why is the death rate very high in the primitive societies? Because we do not have

means of technology - we do not have modern healthcare - that is available, and also most of the works that people do are extremely labor intensive. So, there is a greater probability that people get exposed to say snakes or to other wild animals. There is also a greater chance of death because of sun strokes because people are - because most of the people are working outside. So, in the early - in the early primitive societies - we find a high death rate. To compensate for the high death rate these societies also have a higher birth rate. Now, because there is a high death rate and a high birth rate, so the population more or less remains stable.

Now, with increasing wealth - not because of increasing food supply, but because of increasing wealth - what happens is that more and more people now have access to technologies, more and more people now have access to better health care. And when you have a society that has more access to technologies and better healthcare, what happens is that the death rate starts to fall. When the death rate starts to fall and the birth rate has remained constant, we have a situation where the birth rate is greater than the death rate. Now, it is important to note here that the increase in the population is not because of an increase in the birth rate - the birth rate is the same as what was there in the primitive society. But because the death rate has gone down the difference of birth rate minus death rate that has increased and because of this increase we find that the population starts to grow.

As more and more people have access to this wealth, in a short time they start to realise that yes, the population is growing too fast and earlier where the impetus on every couple was that out of every say 6 or 8 children around 5 children are going to die - so, we need to have more children so that we can ensure that at least a few of them are able to reach till adulthood. But when people start to observe that most of our children are able to reach their adulthood, then there is a less incentive to have more number of children. And so, with increase in wealth we start to observe that first the death rate had gone down, then people start to reduce the birth rate as well.

Now, in all this period till the birth rate comes down to the level of the death rate or to a very reduced level, there is a difference between birth rate and death rate - because of which the population grows. But when the birth rate also comes down then we again have a situation where the population becomes stable.

So, as against the Malthusian theory which stated that the population will always show a geometric progression in its increase, in actual reality we observe that with increasing amount of wealth there is a change in the population growth patterns.

Then, Malthusian theory also did not consider population increase due to lowering of the death rates as we have seen. Also, preventive checks do not pertain only to moral restraint. The Malthusian theory had emphasised a lot on moral restraint, things such as celibacy, things like not having a marriage or things like having a late marriage. So, moral restraint was probably the only option that was available to people then to reduce their population, but these days we also

have access to contraceptives. This is again something that the Malthusian theory does not consider.

Another criticism is that the positive checks may occur even in low populated countries. Now, if you remember, Malthusian theory had stated that positive checks include things such as famines or floods. So, essentially positive checks are those things that nature brings in to reduce the population. And Malthusian theory - because it was a doomsday sort of a theory - it stated that if you do not check your population growth someday nature will come in and bring the population down through these positive checks.

But then what we have observed through time is that positive checks such as earthquakes or floods or tsunamis not only come in those areas that have high populations, but they are also very prevalent in those areas that have a low population such as countries such as Japan. So, this is another criticism. But, if Malthusian theory is unable to explain what causes the growth in the human population, what other theories can be used to help us find out what is causing the growth in the human population?

In this context, we can have certain glimpses from wildlife population ecology. Population growth is not something that is specific only to the human population. We observe population growth in a number of other organisms as well. And especially in the case of wildlife management it is very crucial to know what is the level of population for any species. For instance if you wanted to conserve a species such as tiger, and if you did not know what is the level of population, and if the population is growing or not, you would not be able to make the right decisions. Essentially, if you have a target species and it has not reached to a level that you feel confident that it will not become extinct anymore you would try to increase its population. On the other hand, if you have a species that has increased its population to such an extent that now it is becoming difficult to manage this species you would want to bring the population level down. On the other hand, if there is a species that has reached to a level where you are confident you would want to maintain it at that level. So, a good understanding of the levels of population and what causes population changes is crucial for wildlife management. And a lot of studies have been made in the case of wildlife population ecology. So, can we make certain assumptions or can we understand some of these phenomena from wildlife population ecology?

In the case of wildlife population ecology as well we start with our equation of the exponential growth. Now, let us suppose that a population is showing an exponential increase or it is showing a geometric progression which would say that

$$P[t+1]/P[t] = R[0]$$

Now, this is the same thing that Malthus had said that the population of humans doubles every 25 years. So, R naught is equal to R_0 and the steps of taking time intervals is 25 years. So, at the t

plus 1th step you have a population that is twice that at the t-th step which is what is this equation.

So, N at time t is the population size at time t, N at time t plus 1 is the population size at time t plus 1, and R naught is the constant which in the case of population ecology we call it the net reproductive rate. So, net reproductive rate can also be expressed as the number of female offsprings that are produced per female per generation.

Now, this is represented in terms of females because females give birth and so, if we know the number of females that have been born per female in this generation it gives a very good idea of the rate of population growth. This is how we represent it in the case of population ecology:

$$N[t + 1] = R[0] \times N[t]$$

which is the geometric progression.

If we take any constant R naught, say R naught of 1.5, we will find that the population increases and the rate of increase increases make every generation. So, from the 0th generation with a population size of 10, in the first generation we have a population size of 15, so there is an increase of 5 here.

Now, from the 1st to the 2nd generation there is an increase of 7.5. So, let us write it here. So, here the increase is 5, here the increase is 7.5, here the increase is 11.25. What we are observing here is that with every generation the increase - the net increase which is the population at the nth generation minus the population at the n minus 1th generation, it is increasing, which is a common characteristic of the exponential growth as well.

But then in a short while - in just 10 generations you have increased from 10 to around 400. Now that is not sustainable. Population size - when you plot it versus generation - this is the exponential increase, this is the geometric progression, but then in reality we hardly see any such population increases in nature.

Now, here we are talking about the wildlife population, we are not talking about the human population so far. Because in the case of human population we have seen this curve - that it increases exponentially. But in the case of wildlife populations we see certain differences.

So, this is a theoretical model. But in practice what we observe is that R naught is not constant: it varies with the population size. A good way to understand this is by a thought experiment. Suppose there is an island and this island has plenty of food, and this island has absolutely no predators. And you leave two mice, a male and a female - on this island. Now, these mice have plenty of resources, there is no dearth of food, there is no dearth of space, because all the islands

is available for them. There are no predators to keep their population in check. So, the population of these mice with a starting generation comprising of only two individuals - it will start to increase exponentially, because with every generation we have more mice. And more mice would mean that in their next generation they would have even more number of offsprings, which is this classic curve which shows the exponential increase.

But then after a few generations what would happen is that you would have so many mice that now the food would start becoming a limiting factor. So, earlier when you had this island with plenty of food and you had only two mice, each mouse can eat as much as it wanted. But now the size of the mice population has increased, so much that now not every mouse would be having access to sufficient amount of food.

Similarly, the space that was available earlier was plenty because this island was - because all of this island was available for the mice. But now the population has increased so much that you will now start to see some amount of competition for space. So, there is competition for food, there is competition for space. And so, the mice will now have to fight each other for the resources.

They will not have access to all the resources that they actually need to maintain this sort of a population curve. And when that happens this curve will then start to flatten out. So, it moves like this, but then it will start to flatten out and ultimately it will reach to a flat stage. We are coming to that now.

This is known as the logistic growth equation. Now, the logistic growth equation states that the growth will increase in an exponential manner, but then after some time as the population starts to reach the carrying capacity then the rate of population growth will start to diminish so that afterwards we have a constant population.

This is how we represent the logistic growth equation: it states that

$$\frac{dN}{dt} = r \times N \times (K - N) / K$$

Now, consider the first case where N is very much less than K . N is the population at any time t , K is the carrying capacity. Carrying capacity means the maximum number of individuals that can be sustained by the environment. In the case of our example of the mice on the island, we are referring to the maximum number of mice that can be sustained by the island, that can be provided for in terms of food, water, space, by the island - that is the carrying capacity.

Now, if N is very much less than K which is in the starting - suppose you had a carrying capacity of say 10000 mice, but you only started with 2, so you have 2 which is very much less than K . In that case, K minus N is approximately equal to K because N is very much less than K , so K

minus N is roughly equal to K, which means that K minus N divided by K is approximately equal to 1.

What we are saying here is that this K minus N by K - this portion is roughly equal to 1. When that happens we would have the situation that dN by dt is equal to r into N, because this portion is equal to 1, so we will only have dN by dt is equal to r into N, which is the equation that we began with. The rate of increase is proportional to N which is this one - you will have an exponential growth of increase in the population.

But then what happens? When the population increases so much that it is now close to K. So, let us look at the other extreme. Other extreme is that N has increased so much that it is now approximately equal to K. What we are saying here is that the number of mice is not just 2, but say it has raised to around 9500 or say 9900. Now, the carrying capacity is 10000 and the mice population is 9900. So, the environment is roughly just able to support this mice population. And when it crosses 10000, then some of the mice would have to die. In this case when N is approximately equal to K, we have a situation that K minus N is approximately equal to 0 because K and N are very close together. So, K minus N is very small and we can say that it is tending towards 0. Which would mean that K minus N divided by K is approximately equal to 0 or it is a very small figure.

When that happens this K minus N by K is roughly equal to 0. So, dN by dt is approximately equal to 0. What this is telling us is that dN by dt - the rate of increase in population with time - dN by dt is approximately equal to 0 is telling us that the increase in population with time is roughly equal to 0. Now, if the increase in population is roughly equal to 0 it means that the population has now stabilised; the population is now constant, and it is constant at a level that is roughly equal to K.

So, the population increases, but then it becomes roughly equal to K which is the carrying capacity. This is how the curve will look when we plot it. In the beginning we see that the curve goes on like this. This is the phase where we are seeing an exponential growth. Then, we see a phase where there is a constant growth, and then there is a phase where the the rate of growth is decreasing with time.

If we are discerning things out of wildlife population ecology there are two kinds of things that we should be concerned about. One is the problem of statics: what determines the equilibrium conditions at the average values? What determines what will be the population, what will be the growth rate of population at any point of time? What that means is that when we talk about the human population what we are asking is: how much is the human population? What is the rate of growth at this point of time? And is there anything that we can do about it?

The other thing is the problem of dynamics: how does the population change with time? So, the

factors that are working today - the population that we have today - it is going to change with time. How much would this change be? Can we predict what will be the population in say the year 2100 or 2150 or after that? And what would be the factors that would be regulating this population in that point of time? Say here 2100, what would be the growth rate? What would be the factors that would be regulating this growth rate and the level of population?

So, in this lecture, we started with the impact of humans on the environment. And we recapitulated that the impact is equal to the amount of population into affluence into the level of technology. Then, we also saw that the level of affluence does not increase very fast and technology is also dependent on the population base that we have, because the more number of people that are thinking the faster it is possible to have a newer technology. So, the rate of population growth is the biggest factor that can play a role in deciding the amount of impact that humans are having on their environment. So, we need to understand how the human population has been increasing and what are the factors that are leading to this increase.

From there we went to the Malthusian theory. And Malthus had predicted - he was an English cleric - and he had predicted that - or he had observed that the human population grows in a geometric progression that is in every 25 years the human population doubles. Whereas, the agricultural production grows in arithmetic progression. So, there is only an addition to the agricultural production say in every time span. It does not grow in a geometric progression. And if such a thing happened, then we would very soon have a situation where the human population has increased to a level that it does not have sufficient food. And when such a situation arises then nature will start to act through positive checks. He referred to things as positive checks - things such as there would be war, there would be pestilence, there would be a famine, there would be floods, and these are all different ways through which nature will act to reduce the human population.

So, remember that he said that if the food supply is less as compared to the population, then we will be having floods. Now, through time we have observed that this is not the case - we also have floods in areas where you have a very low population density and sufficient amount of food. There are also a number of criticisms, but this was one major factor in his theory - that if the food is less and human population is more, then positive checks will start to play. And he uphelded people to go for preventive checks which the humans can use themselves - things such as celibacy or things such as late marriage, so that the human population does not increase to a level that it surpasses the food production. Now, through time we have observed that, yes, Malthusian theory does explain some points - it is, but, a model - a simplistic model - there are also a number of nuances that it does not consider. Things such as the human population does not double every 25 years. If you plot the the ah the doubling time over the centuries, you will find that it was as high as say 700 years to as low as say around 35, 40 years. Similarly, the agricultural production is not just moving in an arithmetic progression, but as more and more of land is being brought into agriculture, better technologies, more fertilisers, more application of

fertilisers, we have been able to put even the agricultural production into an exponential phase.

Similarly, the positive checks not only occur where there is a scarcity of food supply, they can also occur in other places. So, there are a number of criticisms to the Malthusian theory. One way out is to look at how different wildlife populations behave. And in the case of wildlife populations, we have observed that the logistic growth equation applies in a number of circumstances.

The logistic growth equation states that if the population is very much less as compared to the carrying capacity of the environment then the population will grow exponentially. Then as the population becomes closer to the carrying capacity the rate of growth will start to go down and ultimately the rate of growth will become 0 in which case the population will become a stable population. So, we see an S-shaped curve in which the in the beginning we have a flat phase followed by exponential which we also call as the lag phase, followed by a log phase, followed by a stationary phase and sometimes also a collapse of the population. This is something that we observe in a number of circumstances.

Now, the exponential phase or the log phase can be continued if the carrying capacity of the environment can be increased which is what the humans have been able to do for quite some time through modern technology and by bringing more and more land under their control. But this can only be done to a certain extent.

Then, we also observed that in the case of wildlife populations there are certain extrinsic and intrinsic factors that play a role in determining the rate of population growth, and humans being no exceptions we can use these extrinsic and intrinsic factors. But also we can make use of incentives because man is a rational organism - man is rational thinker, so we can make use of incentives. We can make use of demographic transition by providing more and more amount of food and resources to populations, so that demographic transition is accelerated and we bring the human population to a level where the birth and death rates both are low.

So, that is all for today. Thank you for your attention. Jai Hind!

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Module 2
What is Conservation?
Lecture 3
Unsustainable development

Namaste! We carry forward our discussion on Conservation, and in this lecture we will have a look at Unsustainable Development. Now, let us begin this lecture by remembering what Gandhi had said, "The world has enough for everyone's needs, but not everyone's greed."

Here Gandhi is emphasising that we have enough resources, but these resources are only sufficient to meet the needs of everybody, but not the greed of people. That is he is emphasising that the resources that we have are limited and while they can be used to fulfil everybody's needs; so, that everybody is well off they cannot be used to fulfil the greed's of people. So, if somebody wants to have more and more of all the resources, then that is not something that can be permitted, because that becomes unsustainable. So, here we are getting an idea of sustainability. If you use resources in such a manner that you are using them to fulfil your needs, it is a sustainable use. But, if you are using things to fulfil your greed, then it is probably an unsustainable use.

Now, technically we define sustainable development, as development that meets the needs of the present, without compromising the ability of the future generations to meet their own needs. So, when we talk about sustainable development we are saying, that we need to have a development and this development should be sufficient to meet the needs of the present. Again it's the same thing - everyone's needs. So, we want to have a development such that we are able to meet the needs of everybody, but without compromising the ability of future generations to meet their own needs. Now, why do we not want to compromise the ability of the future generations to meet their own needs? Because, again that if we are compromising the ability of our future generations, then probably we have shifted from the domain of needs to the domain of greed. And we are using so much of the resources that our children, and our grandchildren will no longer be able to meet their own needs. So, then we will call it an unsustainable development.

So, sustainable development is the development that meets the needs of the present without compromising the ability of the future generations to meet their own needs. And, we have seen before that if the world goes with an unsustainable development then, we have issues; we have

problems of conservation. Some examples of what an unsustainable development can lead to are over consumption - overuse of resources again. Overuse of resources because, we have shifted towards meeting the greed's of some people or greeds of majority of people. That leads to an over consumption. If you have an over consumption you will be clearing off a large portion of the forest to make space for agriculture, to get more and more amount of food, if you go for an over consumption you will deplete the resources, you will deplete the fish stocks, you will deplete the environment, you will deplete the ground water.

So, that is a result of unsustainable development: over consumption. Destruction of habitats which is bringing huge survival questions for a majority of species, desertification because the ground cover has been completely removed, because of the need for food, the need for water and also because of over grazing - that leads to desertification. Ocean acidification because, we are using so much amount of fossil fuels that we have increased the amount of carbon dioxide that is there in the atmosphere. And some of this carbon dioxide is now getting into our ocean waters - it is making the waters acidic. So, that is another consequence of an unsustainable development. Depletion of the ozone layer, changes in the biogeochemical cycles - we have shifted to an unnatural biogeochemical cycle - loss of biodiversity, extinction of species, changes in the distribution of organisms, changes in biodiversity, changes in climate, erosion of soil, changes in geomorphology all of these are some consequences of unsustainable development.

Changes in stratigraphy, changes in the element composition, changes in soil, introduction of invasive species, pollution, bleaching of corals, wars; so, a number of these things are arising, because of the greed of human beings. If everybody was targeting to fulfil their own needs, then the issues would not have arisen.

So, these are some consequences of unsustainable development. Now when we talk about the concept of sustainability - when we say that sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs - then we are talking about two primary concepts. Here the first one is that of the needs of the present. What we are trying to say here is that there is a difference between needs and greed. So, the first concept is the concept of needs, in particular the essential needs of the world's poor to which overriding priority needs to be given.

When we talk about sustainable development we are not saying that we should refrain from development and we should put the world's poor in a position, where they no longer have control over their own lives. No, that is not sustainable development. Sustainable development says that needs of everybody and strictly the needs of the poor people need to be met. So, all the human needs - all the human requirements have to be met.

The second concept is the idea of limitations, or the idea of having a trade off. So, this definition is emphasising that there is always a tradeoff. We can go on meeting the needs, but if we

increase our needs to certain extent then the meeting of those needs will start to affect the ability of the future generations. Then probably that is not right.

So, there is always a trade off. You have to decide how much do you need today and how much needs to be left for the future generations. There is always this trade off that goes, there is always this idea of limitations, which is imposed by the current state of technology and social organisation.

On the environment's ability to meet the present and the future needs - the ability of the environment to meet the needs of the present as well as of the future generations is limited and so, this has to be kept in mind whenever we are trying to meet the needs of the present generation, or whenever we are trying to leave resources for the future generations.

We recognise three pillars of sustainability; we can talk about environmental sustainability, economic sustainability and social sustainability. So, these are the three pillars of sustainability: environmental, economic and social sustainability. What are these?

When we talk about environmental sustainability, we talk about things such as ecosystem services. Ecosystem services are the services that are provided to human beings by a well functioning ecosystem. So, these are things such as reduction of pollution, provisioning of services such as goods, things such as wood, fodder, fuel. We also have things like maintenance and regulation of the local climates and the microclimate. The benefits of biodiversity including things such as pollination or protection from certain diseases, availability of medicinal plants - these are all different ecosystem services which are provided by an ecosystem that is functioning well. And when we talk about environmental sustainability, we need to ensure that the ecosystem services are provided to the present generation and also to the future generations - which means that the ecosystems should be in a position where they are able to work properly. So, that is a part of environmental sustainability.

Then, we talk about things such as green engineering and chemistry. How can you manufacture goods or services in a manner that is less polluting to the environment? So, for instance, could you, say, replace a few chemicals that are inside a bottle - inside a plastic bottle, in such a way that when these chemicals leach out into the environment then they cause lesser degree of harm? When we start thinking about these things then we are talking about green chemistry. Can we replace plastics with biodegradable materials - bioplastics? So, this is also another concept in green engineering. In environmental sustainability we also talk about the quality of air and water, especially the levels of pollution that are there. We talk about reducing the effects of stresses such as pollution, greenhouse gas emissions and so on. So, if you want to maintain the sustainability of the environment you need to keep these stresses down to a certain level. We talk about resource integrity by minimising waste generation to prevent accidental release in the future.

So, when you talk about environmental sustainability there are two options, one to go with the business as usual, where you are generating a huge amount of waste. And, you are probably keeping this waste in a landfill or keeping them in containers, you are storing, say, chemical wastes or radioactive wastes in containers. And whenever you have such a situation, then it is possible that the future generations are going to pay for our misdeeds. Because, it is possible that in a near or a far off future, some of these chemicals may start to leach out. In that case we are putting a liability to the future generations.

So, when we talk about environmental sustainability, we say that no, we should go for such processes that the amount of waste generation is minimised, so that there is a lesser need to keep these wastes in a storage, which could cause an accidental release or issues for the future generation. So, we want to have the resources today, but we want to have them in such a manner that we are not creating a liability for the future generations. That is a part of environmental sustainability.

When we talk about social sustainability, we talk about things such as environmental justice, empowerment of communities that are burdened by pollution. In social sustainability, we have things such as the rights of the local communities. Suppose there is a big mining firm and it says that ok, I need these forests because below these forests we have a huge amount of minerals - we have a a a huge stock of ores. Now do you just permit this company to go cut the forest and start digging out the ores, or do you also ask the local communities?

Now, there could be certain communities who have been protecting these forests - because these forests are part of their culture. So, do they have a right or not? And if we say that these people also have a right, then we are talking about social sustainability. Similarly, in one of the later lectures we will have a look at things such as industrial pollution. If there is a company that is releasing chemical waste into the seas, and the fishermen who are catching the fish that are laced with these poisonous chemicals - they are losing out their jobs. The local community that is feeding on these fishes is falling ill. Do these people also have a right? And when we say that they also have a right to life, we are talking about things - which is social sustainability. In social sustainability, we talk about protection, sustenance and improvement of human health. Because again when we talk about the ability of the future generations to meet their own needs, then if the future generation is healthy then they will be in a much better position to meet their own needs.

And so, we need to ensure that we are not spreading pollution or industrial effluents to such an extent that it is impacting the health of any community. So, this is a component of social sustainability. Or things like increasing the participation of stakeholders - and here again the future generation will be in a much better position to fulfil their needs, if they have been involved in the decision making process - if they have been trained in the decision making process, if they know how to say bargain for things, if they know how to negotiate for things. So,

when we talk about social sustainability it is important to ensure that all the stakeholders get the right they have and they get a voice.

Whenever you need to make any decision - whether any industry should be set up, where should it be set up, what will be the modalities of collection of the effluents, or treatment of the effluents then the local people have to be involved. And when we talk about such stakeholder rights, we are talking about social sustainability.

Education about sustainability - the future generations will be in a much lesser position to meet their dreams, if they are uneducated. So, in social sustainability we also say that people need to be educated about sustainability. Sustainability is something that should be incorporated in the textbooks, sustainability is something that should be taught in the schools. Because, when people are educated about sustainability they will be in a much better position to assert their rights and they will have a much better control over their lives. Another thing that we talk about is the protection, maintenance and access to resources - protection of resources, maintenance of resources and access to the resources.

Let us take the example of a tiger reserve. Currently there are certain communities that are living alongside a tiger reserve. And their livelihoods are dependent on the tiger reserve because there are people who want to see tigers - they come to these tiger reserves and tourism industry is providing jobs to these local communities. Now, what will happen if all the tigers get forced out? If there are no tigers in a tiger reserve, there would be hardly any tourists who would want to visit the place. So, the protection and maintenance of tigers - here tigers are a resource - they are a natural resource and maintenance and protection of these tigers is critical to ensure that the future generations are also able to derive their livelihoods or employment through this resource. Similarly people need to have an access to the resources. Now, suppose the government comes up with a policy and says that ok, there is this tiger reserve, but all the facilities of tourism will be say set up and maintained by a third party. And we are not allowing the locals to have an access to this area or to the resources. In that case the ability of the future generations of these communities to derive their livelihoods and employment from these tigers or these tiger reserves will go down.

So, in social sustainability we need to ensure that the resources are protected, the resources are maintained in a good fashion and people also have access to these resources. We talk about promotion of sustainable living - that is also a component of social sustainability. Because, if people shift to living in a sustainable manner, then the next generations are in a much better position to meet their own needs. So, this is also another component of social sustainability.

Next, we talk about economic sustainability. In economic sustainability we talk about job security. If there is a resource - does it provide job security to people, or when we are talking about a tiger reserve is the condition such that people have a job one day and next day they can

be kicked out? If that is the situation - if the local people do not have a job security, then probably this is not a sustainable development. Because, the locals - or the people who are dependent on these tiger reserves - also need to be sure that they will be in a position to utilise these resources to meet their needs. So, in economic sustainability we talk about job security, we talk about incentivisation of sustainable practices. We have seen before that incentives are things that induce people to act in a certain manner. If you - if the society wants to promote sustainable living, then sustainable living needs to be incentivised. A good way out is through the provisioning of taxes and subsidies. If somebody is going towards an unsustainable living, then probably the government may tax that person more - which is why the government taxes polluting vehicles in a big way.

By these taxations the government is incentivising people to refrain from using these oil guzzling vehicles and pollution spewing vehicles. In a number of cases these incentives are also positive incentives such as subsidies. So, in a number of cases the government subsidises the purchase of electric vehicles, the government gives you a subsidy if you put up solar panels on top of your roof.

So, economic sustainability talks about the use of incentives to promote sustainability. It talks also about the market practices for sustainability: how do you tinker the market in such a manner that sustainability gets promoted. We will look at the functioning of markets in later lectures, but here it is important to emphasise that the demand for things depends on a number of factors, including whether people have been exposed to it and how culturally or socially acceptable is the using of a certain resource. Now, if through education or through awareness people get this idea that the use of solar panels is sustainable, or the use of SUVs is bad for the environment - that would impact the demand of these resources. And demand would also have an impact on the supply of these resources, on the prices of these resources.

Economic sustainability also talks about the market practices for sustainability, it talks about natural resource accounting. When we do an accounting for any industry is it only the profit and loss statements that we are interested in, or are we also interested in accounting for how sustainable was the manufacturing process?

Natural resource accounting incorporates things such as the sustainability accounting for industries; it also incorporates accounting for how much amount of resources do you have. Does the country say for instance perform an audit every few years about how much is the stock of forest that is available in the country, how much is the amount of groundwater that we have in the country, how much is the level of fish stocks in the country? When we incorporate accounting for all of these different natural resources, we are talking about economic sustainability.

Life cycle cost assessment: a very good example in the case of life cycle cost assessment is

plastics. Plastics are so ubiquitous because they are cheap to manufacture. So, it is very easy and it is very cheap to manufacture, say, a plastic bag or a plastic bottle. But once they have been used and once they have been thrown out, then it is difficult to collect them: especially because they are light in weight and they litter easily. It is difficult to carry them to say a sorting facility because again because of their light weight they use a very large volume - and so, transportation becomes difficult. It is difficult to sort them out into different categories because there are so many different kinds of plastics. There are so many different kinds of additives that we are adding to plastics - there are so many different kinds of plasticizers that are added. We have thermoplastics, we have thermosetting plastics - both of these cannot be mixed together, if you are aiming to recycle plastics. Then, when if these plastics are recycled, then there is a cost to recycling, if these plastics are put into a landfill, then there is a cost of land and water. Now, the person who is manufacturing the plastic or the industrialist who is manufacturing these plastics or these plastic bags is not paying for all of these - it is the society that is paying for these.

So, the municipal corporation of your city will be paying for say collection of garbage or processing of garbage or disposal of garbage. When we say that the municipal corporation is paying, it is the taxpayers who are paying, it is you and me who are paying for the disposal of these plastics - it's not the industrialist. So, if we emphasise that plastics are cheap - because they are cheap to manufacture, then it would be one story and if we emphasise that throughout their life cycle from their cradle to their grave, the plastics have such and such cost involved - the cost of collection, the cost of transportation, the cost of processing and the cost of keeping them stored for say 1000 of years - because they just do not degrade. When we incorporate all of these costs into the accounting we are talking about the life cycle assessment of plastics. And once we incorporate life cycle assessment, we will see that a number of biodegradable products are much cheaper than plastics. It is only because we do not consider the life cycle assessment that we say that plastics are cheap. If we incorporate life cycle assessment, we realise how expensive they are. Now, incorporation of life cycle assessments is important for conservation, but it needs to be done. And when we talk about life cycle assessments, we are talking about economic sustainability.

Then, in economic sustainability we talk about cost structures to reduce the risk and to promote new technologies. So, for instance if there is an industry which is a polluting industry, and this industry has an option to say install an equipment that would process these pollutants - but the installation of these equipment will entail certain cost. There could also be a requirement for putting money into research, for development of such technologies which will be able to control this pollution. Now, these sorts of things need to be incentivised. So, you need to incentivise industries to install such equipment, you need to incentivise the research institutions to perform research into developing these technologies. And, when we say that all of these are important and they need to be funded, say, by the government, we are talking about economic sustainability.

And when we incorporate all these three - the social accounting, environmental accounting and the financial accounting, then we are talking about the triple bottom line. Now, bottom line generally refers to the last line in the profit and loss statement. And it tells what is the level of profit or loss that a company has had in a particular year - that is the bottom line. But, then the triple bottom line says that not just the profit and loss, but you also need to see, if the social accounting and environmental accounting have also been a part of the functioning of this industry or company.

When we talk about sustainability, there are two different schools of thought. There is one school of thought that says that ok, we need to have sustainable development. But, we can say do a trade over or a trade off for meeting the needs of the present in a much greater way than meeting the needs of the future generations. That is weak sustainability. And there is another school of thought that says that no matter what happens the development has to be sustainable. You cannot trade the needs of the future generations with the needs of the present generation - that is the strong sustainability. So, weak sustainability assumes that natural capital and manufactured capital are essentially substitutable - natural capital such as forest and the manufactured capital such as say iron ore - weak sustainability says that both of these are essentially substitutable, which means that if you are destroying your forest, but, by destroying the forest you are having more and more industries or you are having more and more roads, or you are having more and more production of iron, then it is ok if the forest get destroyed. That is weak sustainability - it assumes that natural capital and manufactured capital are essentially substitutable. And it considers that there are no essential differences between the kinds of wellbeing that they generated. So, they are one and the same - the only thing that matters is the total value of the aggregate stock of capital, which includes the natural capital and the manufactured capital, which should be at least maintained or ideally increased for the sake of the future generations. It says that if we get rid of our forest, but we have developed an industry in its place, so through this industry the future generation will be able to meet its own needs - so there is no need to conserve the forest. That is weak sustainability - that natural capital and manufactured capital are essentially substituting. In such a perspective it does not matter whether the current generation uses up non renewable resources or dumps carbon dioxide in the atmosphere, as long as enough machines, roads and ports are built in compensation. This is weak sustainability.

The strong sustainability school assumes that natural capital and manufactured capital are essentially non substituting. It says that you need to maintain natural capital and you also need to maintain the manufactured capital. And you need to maintain both of these; you cannot just say that we will be maintaining the manufactured capital at the cost of the natural capital. That is the strong sustainability. It considers that there are essential differences between the kinds of well being that they generate. So, essentially you cannot substitute the joy of seeing a tiger by say providing a longer road. So, this is what the strong sustainability argument says - that the benefits that we receive out of the natural capital are very different from the benefit that you receive out of the manufactured capital. And so, when we talk about sustainability, we need to

maintain both of these capitals separately. Both natural capital and manufactured capital need to be at least maintained or ideally increased for the sake of the future generations. So, it says that the natural capital and the manufactured capital both need to be maintained and both need to be ideally increased for the sake of the future generations. That is if you look at the differences between strong and weak sustainability, the key idea in strong sustainability is that the substitutability of natural capital by other types of capital is severely limited, they are not substitutable. The weak sustainability on the other hand says that natural capital and other types of capital such as manufactured capital are perfectly substitutable and you can trade off one for the other. Strong sustainability says that certain human actions can entail irreversible consequences. A good example is climate change. It says that if you go and releasing large amounts of carbon dioxide into the atmosphere that would lead to global warming because of the greenhouse effect - and that could lead to climate change. Now, climate change essentially is an irreversible phenomenon and so, it will lead to consequences that are also irreversible. Weak sustainability says the technological innovation and monetary compensation can be done for environmental degradation. That is, on the one hand the strong sustainability argument would say that you should not release so much amounts of carbon dioxide because that will lead to climate changes and that would lead to negative consequences for a large number of people, on the other hand weak sustainability says that ok, even if there is climate change, we can provide monetary compensation to the people who are affected by climate change. So, weak sustainability would say that ok it is fine that there is climate change. You can always compensate people for it we can provide them with money. And, they should be happy with it and so, there is no need for the present generation to say stop climate change.

This is a major difference between ah the strong and the weak sustainability. The strong sustainability says that conserving the irreplaceable stocks of critical natural capital for the sake of future generation is essential because a number of stocks of natural capital are irreplaceable - you cannot replace them with anything else. The weak sustainability says that the total value of the aggregate stock of capital should be maintained or ideally increased - not natural capital. So, this is a difference between strong and weak sustainability. The key concept in strong sustainability is critical natural capital - it tries to emphasise again and again that the natural capital is critical. On the other hand the weak sustainability just says that optimal allocation of scarce resources is good enough.

The strong sustainability says that scientific knowledge is required as an input for public deliberation - it talks about procedural rationality. It says that scientific knowledge is crucial, and we need to develop these procedures. On the other hand the weak sustainability only talks about technical or scientific approach for determining the thresholds and norms - it is talking about instrumental rationality. So, on the one hand the strong sustainability is asking how are we going to conserve these natural capital, but weak sustainability is only saying that ok even if the national capital is going down we just need a method to measure this loss of natural capital, so that we are able to compensate for it by providing money. It only talks about a technical aspect, it only talks about an instrumental rationality not a procedural rationality.

Sustainability these days has come into our common currency, especially after the Earth summit of 1992. In the earth summit the countries came together and they agreed to agenda 21 - which is the sustainable development in the 21st century. This talks about sustainable development goals. These include things such as no poverty, or reduction of poverty - so, here we are talking about a social sustainability as well as as an economic sustainability. It talks about removing hunger - because, if you create conditions where people are no longer poor or hungry, then probably they - as well as their next generations - will be in a much better position, to ah fulfil their own needs and requirements. It talks about things such as good health and well being - which is crucial not just for the current generation, but also for the future generations. It talks about quality education to people. It talks about gender equality, clean water and sanitation, affordable and clean energy - not just clean energy - the energy needs to be affordable, so that more and more people have access to the energy.

But, then in the quest for making energy affordable, we just cannot go on with the non renewable sources of energy. We have to shift towards clean energy - and we need to to create such conditions that clean energy also becomes affordable. So, we need to invest into research into clean energy, we need to invest into those industries that are producing - say - the solar panels. We need to provide incentives to people - we need to provide subsidies, so that clean energy becomes affordable. So, affordable and clean energy is a sustainable goal. Decent work and economic growth - now we are starting to talk about economic sustainability: everybody should have an opportunity for a decent work, and should also have the opportunities of economic growth, industry innovation and infrastructure.

So, you need to have infrastructures, you need to have industries, which will make it possible for the future generations to meet their own needs. Reduced inequalities, sustainable cities and communities - so not just sustainability at the level of the industries; but also sustainability at the level of cities. Is your city in a position where it is doing rainwater harvesting? Is your city, for instance, having a sewage treatment plant, and even more preferably a sewage treatment plant that makes use of bio remediation - because that is one of the most sustainable ways in which we can process the waste. So, the sustainable development goals talk about sustainable cities and communities.

They, talk about responsible consumption and production - consumption needs to be responsible - which means that over consumption needs to be avoided. So, there is responsible consumption, but also responsible production. Responsible production is production in a manner where we are not overusing the natural resources - we are not generating a huge amount of waste. We are doing the production in some of the most efficient manners - we are doing production that uses clean energy. That is responsible production.

So, the sustainable development goals talk about responsible consumption and responsible

production. They talk about climate action: What are we doing to mitigate the climate change? It talks about life below water. It talks about water habitats - the aquatic habitats - are they functioning well? What about the fish stocks? Are we over consuming the fish stocks? That also needs to be kept in mind.

Also in one of the sustainable developing goals, it talks about life on land which includes biodiversity. Are we doing our development in a manner that conserves biodiversity, or are we doing our development in a way that is getting rid of biodiversity? It talks about peace, justice and strong institutions - because once we have peace, once we have justice, and once we have strong institutions, then it creates a society in which people have much more control over their own lives. It creates a society where everybody is able to develop himself or herself. And it creates a society in which not just the present generation, but also the future generations will be in a much better position, to say, do innovation or to have more control over their own lives.

The sustainable development goals talk about maintaining peace. If there is a war then probably the next generation will be in a much worse position to maintain their own needs. It talks about justice, it talks about institutions, and it also talks about partnerships for the goals - because of late we have realised that sustainability cannot be done at the level of just a single country. If for instance there is one country that is releasing a huge quantity of greenhouse gases, it is over using coal - then the consequences will not just be faced by that country, but also by the world in total - because climate change is a global phenomenon. If there is a country that is burning a huge quantity of coal - then the acid rain that results will not just fall in that country, but will also fall in the neighbouring countries. If there is a radioactive substance release from one country, then this radioactive elements will move through wind and water to reach other countries, they will affect people in the other countries as well. So we require strong partnerships and we require common goals.

These are the sustainable development goals. Can you relate these to the 10 principles of economies? One: people in society face tradeoffs - and when we talk about sustainability, we are talking about the tradeoff between meeting the needs of the present generation and meeting the needs of the future generations. Sustainability says that we need to meet the needs of the present generation, in such a manner that the future generations are also able to meet their own needs. This is a tradeoff. Tradeoff of course, and you need to cost what you give up to get something.

If you want to do development in such a manner that your children and your grandchildren are also able to have control over their own lives, then you will have to forgo something. Cost as we have seen is what you give up to get something. And, if you want to perform development in a manner that your future generation is secure then probably you will have to reduce your own consumption.

So, tradeoffs lead to costs and sustainable development talks about these costs. Third: that people

respond to incentives. So, if you want to promote sustainable development you will have to incentivise sustainable development, and you will also have to disincentivized development that is not sustainable. And we have seen that taxes and subsidies are very good mechanisms. But we also have social incentives.

Is the society boycotting an industrialist who is polluting the surroundings? Is the society honouring an industrialist who is - say making an express effort to reduce pollution? When you go and buy an equipment - do you only look at the cost or do you also see, whether or not that industry is making the equipment in a sustainable manner?

We can also look at the energy audits of the industry - do you also look at the natural resource audit of the industry? If you do all of these then probably, you are incentivising sustainable development and disincentivizing unsustainable development.

So, people respond to incentives, industries respond to incentives - and it is not just the role of government, but also of each and every consumer. Then, we saw that markets are usually a good way to organise economic activity and so, if we want to promote sustainable development, we will also have to act at the level of the market. And markets can be influenced. Markets can be influenced by influencing the buyers and by influencing the selling.

Governments can sometimes improve the market outcomes, through interventions - and these interventions can be at the level of taxation, subsidies or direct command and control. So, we can make use of different principles of economics to ensure that we have a sustainable development. So, what kinds of things should be we promoting? And what sorts of things are being promoted?

One thing that is being promoted for sustainable development is clean technology. Clean technology refers to any process, product or service that reduces negative environmental impacts, through significant energy efficiency improvements, sustainable use of resources or environmental protection activities.

Clean technology is any process product or service - so, we can have it at the level of a process, we can have it at the level of product or we can have a clean technology even in the service industry. And, what does clean technology do? It reduces negative environmental impacts. And how does it reduce the negative environmental impact? By doing significant energy efficiency.

Here we are talking about such processes, or such products, or such services that keep in mind that the energy efficiency needs to be increased. Now, the best thing about increasing energy efficiency is that it also makes the industry or the process more profitable. So, for instance there are two methods of manufacturing a chemical. And the first one takes say 1 mega joule of energy. And the second one takes 10 mega joules of energy for the same quantity of product. Now, if the industry shifts towards the process that is taking just 1 mega joule of energy, then

probably the industry will also be doing significant cost cuttings, because of reduction in its energy usage - the bill for energy will go down. It is important that we incentivise such processes because, in the beginning it might be difficult for the industry to shift to a more energy efficient process or protocol. Because, it might require, say, installation of a different equipment. But, in the case of clean technology we try to increase the energy efficiency - or it promotes the sustainable use of resources, or it promotes environmental protection activities.

So, for instance if there is a product - or let us say that there are two packets of tea and one says that it has been sourced from those areas that are doing organic cultivation. And the second one does not do that. In that case if you purchase the one that has been sourced from organic farms, then you are promoting sustainability.

Or there could be say a chocolate that says that it has been taken from those farms, or those countries that do not permit child labour. Or if you purchase a mobile phone that says that when it was manufactured, we took care that the greenhouse emissions were net zero. If we are using these services or if we are using these processes or these products, what we are doing? We are promoting clean technology, which will lead to sustainability. Now, things in clean technology include renewable energy, water purification air purification, sewage treatment, environmental remediation, solid waste management, energy conservation and appropriate sustainable technologies.

Let us have a look at some clean technologies that have been incentivised. One is environmental friendly energy and energy storage, including things such as power generation with renewable energy, use of photovoltaics or solar panels, use of solar thermals - solar thermals are those power plants that make use of the heat that is given out by the Sun in the form of infrared radiation. It concentrates that heat and it uses that heat to run a turbine. So, it is different from a normal solar cell. Or energy generation using geothermal energy, which is the heat that is stored inside the Earth. Or power generation using wind energy, or power generation using bio energy or power generation using sewage gas. Another clean technology is the environmental friendly use of fossil fuels. In this case you are using the fossil fuels, but you are using them in a way that is more environmental friendly.

Remember that when we talk about clean technologies, we are only talking about increasing the energy efficiency, or shifting from a 100 percent fossil fuel to a less amount of fossil fuel. It is not necessary that it should be a 100 percent shift. Because, clean technologies are to promote an incremental step - it is a gradual process. So, in the case of environmental friendly use of fossil fuels, we are still using fossil fuels. And it is important to remember that fossil fuels are non renewable energy resources.

They are limited and so, they need to be avoided, but then in cases where they cannot be avoided, we can at least shift to an environmental friendly use. Such as a combined cycle power

plant - in a combined cycle power plant, we use several heat engines together to increase the efficiency. So, in this power plant we are still using the fossil fuel, but by using a number of heat engines, we are increasing the efficiency.

Another is cogeneration plants where we have a simultaneous generation of electricity and useful heat. Now, this heat could be used to say heat up the buildings. So, cogeneration plants ensure that the heat that was released in the generation of electricity - that is also tapped - and that is also used, so that the heating cost somewhere else can go down.

Or shift to high performance power station. Or carbon dioxide reduced power generation. So, you can shift to a process that is still using fossil fuels -but you release less amount of carbon dioxide. Or we can shift to storage technologies such as mechanical storage of energy, electrochemical storage of energy, electrical storage of energy, thermal storage of energy. Storage technologies are clean technologies because they permit people to generate more and more amount of energy through renewable means, when they are available, store that energy and use them when the renewable energy is not available. A good example is solar cells - solar cells or solar panels will only work during the day time, when the Sun is there, but what about the night time? If you wanted to shift to solar panels, then you would have to devise a mechanism through which the energy or the electricity that is generated during the daytime can be stored. Now, this storage can be through means of a mechanical storage, for instance you can use the solar energy in the daytime, to run pumps and shift water to a higher level. And, in the night time this water can be made to run through turbines and get the energy back. So, in this way we will be able to store the electricity that was generated through sustainable means, or through renewable energy. Or we can go with electrochemical storage which is batteries - or we can go through electrical storage or thermal storage.

Another clean technology is efficient grids such as smart grid local - local and district heat grid. When electricity is moved from one place to another there is a huge loss that occurs, because this electricity is converted into heat energy. Through a smart grid, we can reduce the amount of energy losses during transport of electricity.

Another clean technology is in the circular economy section, such as waste collection and transportation. If you develop an infrastructure for increasing waste collection and transportation, you are working in clean technology. If you devise a method of base separation and sorting - so that the plastics can be recycled, then we are talking about a clean technology.

Or utilisation of waste through say recycling. If you devise a method through which plastics can be recycled into other product, then we are talking about clean technology. Or thermal waste treatment - we have waste disposal safeguarding and removal of contaminants and hazardous waste, that is also a clean technology. Reduction or utilisation of landfill gas - when we talk about a landfill the organic material that is put into the landfill is slowly converted into methane

and is released. Methane is a very potent greenhouse gas. It acts in a way that is very similar to carbon dioxide, but is much more effective than carbon dioxide in trapping the Sun's heat. If this gas can be reduced or it can be utilised in some way - because methane can always be burnt! So, if you devise a technology through which these landfill gases can be burnt to generate electricity, we are talking about clean technologies. Or, environmental remediation - bringing the environment back to the normal pristine state, such as land rehabilitation or ecological restoration. If we for instance devise a technology through which the holes that are left on the ground after a mining operation - they can be filled back again or they can be replanted. Then we are talking about a clean technology. Or sustainable water management such as water procurement and treatment including groundwater monitoring and water purification. If you devise a technology that can monitor the amounts of groundwater that you have - that is a clean technology, because that permits us to use water in a more sustainable manner. If you devise a technology that can purify water, especially the sea water, then we are talking about sustainable water management because, we will reduce our dependence on groundwater, which is a very crucial natural resource.

If we say tap out most of the groundwater, then it takes hundreds of years for the reservoirs to fill back again. And, if we did tap all the groundwater resources then probably we are leaving out less for the future generations. But, if you devise a technology through which ah sea water can be purified and used - in that case we will reduce our dependence on groundwater and that will be a sustainable use of groundwater.

Or things about water utilisation - that is if we could have ways of increasing the efficiency of the components of the water distribution system, reducing the losses there, working on a on a better water distribution grid - these are all different clean technologies. Or increasing the efficiency in water utilisation - can we talk about water efficient technologies in the residential sector, can we talk about say systems that use less amount of water? Can we talk about water efficient technologies in the commercial sector, or have clean technologies in the sustainable mobility sector, such as alternative fuels, biofuels, natural gas, hybrid drives, electric drives fuel cell drives? Now, many of these reduce our dependence on petroleum. Or alternative drive technologies - efficient combustion engines, environmentally friendly vehicle design or infrastructure and traffic control. If you have an inefficient traffic control, then probably a lot more people are spending their time, in the intersections with the traffic lights. And that is also leading to the usage of fossil fuels that could be avoided. Through an efficient traffic control, an intelligent traffic control, integrated traffic infrastructure, these can be avoided. Electricity charging stations, natural gas fuelling stations - if we are promoting these we are promoting clean technologies.

Or sustainable mobility management such as car-sharing. If you develop an app that that can promote people to go for a car-sharing arrangement or a car pooling arrangement, we are talking about a clean technology. Or vehicle fleet management.

Similarly, we also have clean technologies in resource and material efficiency. Cross sectional technologies such as biotechnology, nanotechnology, mechanical engineering and process technology, new materials such as compound materials and bioplastics. Compound materials in a number of cases are able to increase energy efficiency by reducing the weight of the equipment. Biomaterials such as bioplastics are very good alternatives to petroleum based plastics, and they are biodegradable. Or we can talk about material efficient processes, such as optimisation of existing processes or utilisation of new materials, or reduction of the operating supplies. So, in this case we are saying that we will be using the same process, but we will try to increase the efficiency so, that less amount of raw materials are required.

Or sustainable designing such as eco design, which is an approach to designing products with special consideration for the environmental impacts of the product during its whole life cycle, or life cycle assessment. As we have seen, if we did a proper life cycle assessment, then we will come to the conclusion that plastics are very expensive. So, life cycle assessment is also a component of clean technologies. Or increasing the energy efficiency, such as industry specific energy efficient production processes. Automation control technologies, efficient engines, recovery of feed that would otherwise have been lost to the environment, or making use of more efficient appliances electric appliances, information and communication technology appliances or illumination - if you are shifting from a standard incandescent bulb to say an LED bulb - it is an efficient appliance. This is a clean technology. Or energy efficient buildings - if you look at the technical part or the equipments or build a building shell - which means insulation and windows so that you are able to reduce the amount of heating and cooling that is required in the building - that is a clean technology.

What we are seeing is that especially after the Earth Summit, and especially after agenda 21, a number of governments have been promoting sustainable technologies or clean technologies in a number of different sectors. So, sustainable development is not very difficult, but it does involve a tradeoff - it does involve a cost and if the society is ready it is easy to do.

That's all for today. Thank you for your attention. Jai Hind!

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Module 3
Modern impacts necessitating conservation
Lecture 1
Climate change

Namaste!

Today we begin a new module which is Modern Impacts Necessitating Conservation. In this module we will have a look at certain impacts of human activities because of which conservation has become more important these days. And we will focus our attention on three such impacts climate change, plastics and oil spills and mining.

Let us begin with Climate Change. What is Climate? Climate is defined as: a broad composite of the average conditions of a region measured in terms of such things as temperature amount of rainfall or snowfall snow and ice cover and winds. Climate is a broad composite - which means that, we are not looking at climate in terms of final quantities, we are looking at it as a broad composite of the average conditions of a region - which means that climate is different from weather. Weather changes every day with the changes in a few hours, but climate - because it is a broad composite, it is an average that is taken over several years.

Climate is more or less a constant quantity. It is a broad composite of average conditions of a region measured in terms of such things as temperature amount of rainfall or a snow fall, snow and ice cover and winds. These are different variables through which we describe the climate of a place. When we talk about the average conditions, the classical period for taking these averages is 30 years. It is a pretty long period of time in which we take the averages because of which the climate is fairly representative of the conditions of any region. Even though the conditions might change on an hourly basis or on a daily basis, but on an average the climate will be a very good representation.

How does climate act? There are five components of the climate system. We have the ocean or the hydrosphere, we have land or the lithosphere, we have the winds or the atmosphere, we have the biotic components or the biosphere and we have the ice or the snow cover which is the cryosphere. So, there are these five different components from the climatic system and all five of these interact with each other continuously. For instance if there is a change in the wind condi-

tion, then there might also be certain changes in the biotic composition of the area or when the winds blow over the mountains, then there are changes such as reduction in the debris or snow fall of the area. So, these five components continuously interact with each other.

If climate is an average condition, why do we talk about climate change? When we talk about climate change because even these averages are changing.

How do we define climate change? Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability which is persisting for an extended period of time which is typically decades or even longer. Climate change may be due to natural internal processes or because of external forcings or due to persistent anthropogenic changes in the composition of the atmosphere or in land use.

How can the climate change? The climate change may be due to natural internal processes or because of external forces. What does that mean? Remember that when we said that when we were talking about climate there are these five different components of climate and there are some natural processes that are changing these components. For instance, there might be changes in the tectonic layers of the Earth. The Earth is divided into a number of plates and these plates are in constant movement. When the land surface changes because of the natural processes, then that might change the climate. So, the climate change may occur because of the natural internal processes.

Or it may occur because of external forcings. Now what are external forcings? You have the climate system and there is something that is acting from outside which is resulting in a response to this climate change. We will explore what are these somethings - what are these forcings?

It can be due to natural internal processes or external forcings or also due to persistent anthropogenic changes. Anthropogenic changes means man made changes in the composition of atmosphere or in the land use. Humans are changing the composition of the atmosphere, humans are changing the land use and because of this also we will we can have changes in the climate. So, the next question is, what are these forcings and what are the kinds of responses that we can have?

These are some common forcings: Changes in the plate tectonics. These are changes in the land and sea distribution of the earth because of movements of different plates or changes in the Earth's orbit. Even the orbit of the Earth changes - and these changes occur over thousands of years. Because of changes in the Earth's orbit, if the Earth comes closer to the Sun then the Earth will warm up, if the Earth moves away from the Sun then the Earth will cool down. Or changes in the strength of the Sun. The Sun gives out energy which is regulating the climate on the planet - and this energy is not fixed - it changes. Now, if it so happens that the Sun starts to give out more energy, more amount of heat to the Earth then that would result in a change in the climate -

the Earth will warm up, and there will be changes in the wind patterns. If the Sun starts to give out less amount of energy the Earth will cool down - that will also bring out changes in the wind patterns, changes in the biosphere, changes in the hydrosphere.

So these are also forcings. But the most important forcing these days is the anthropogenic forcing. Anthropos means human and genesis is formation or production. So, anthropogenic forcing is a forcing that has been produced by human beings. What can they be?

The most important anthropogenic forcings or modes of anthropogenic forcings include things such as the release of greenhouse gases such as carbon dioxide. Now greenhouse gases are those gases in the atmosphere that act as a green house by trapping the heat of the Sun in the atmosphere. While they permit the short wavelength radiations of the Sun to enter through the atmosphere and reach to the land surface, once the land surface is heated and it re-radiates the radiation in the form of longer wavelength radiations, then these gases trap them - they do not permit them to move outside to the outer space.

These greenhouse gases such as carbon dioxide or methane are being produced at a much larger level by humans and that is an important anthropogenic forcing. Now how do humans produce a heavy amount of carbon dioxide? By burning fossil fuels such as petroleum, natural gas or coal. How do humans aid in the release of methane? By having more and more number of livestock. Not only do humans release these gases, but they also are acting upon in reducing those modes that would have reduced these gases in the atmosphere.

Plants for instance capture this carbon dioxide and convert them into biomass. And when they do that in the process of photosynthesis, they reduce the concentration of carbon dioxide from the atmosphere. But in our quest for having more food, in our quest for having more land for construction, what we are doing is that we are cutting off the trees. When the trees are cut then less and less amount of carbon dioxide is brought back from the atmosphere into the lithosphere. Also things such as burning of the trees - forest fires - a majority of them are anthropogenic - they are manmade. And why would man want to burn forests? For they want to clear off the land.

If somebody wants to encroach upon a forest land and convert it into an agricultural field, it is very easy to burn the forest. And once the land is cleared then the land can be brought up for cultivation. Or the production of things such as concrete. Concrete production releases a huge amount of carbon dioxide when the calcium carbonate is heated. These are all different modes through which humans are aiding in changing of climate by providing a forcing.

Now, when there is a forcing on the climate system, it results in a response. And what are those responses? Responses could be changes in the atmosphere, changes in the wind pattern or changes in the ocean, etc. Now this may result in changes in say the flow of the ocean currents or

changes in vegetation or changes in land surface or changes in ice. If the Earth heats up then more and more of ice will melt and the water will get into the ocean. You will have a larger volume of water that is there in the ocean and even this water - when it gets heated up - it will expand. This is a response that we will see because of the forcing of increasing the temperature.

And these responses manifest in the form of heat waves, they manifest in the form of changes in the ice pattern, they manifest in the form of droughts or floods or increased temperatures in a number of areas or in the form of forest fires. So, these are several responses that we are observing because of changes in the climate and these also result in biological responses.

So, the climate change results in changes in the temperature. There is a change in the mean temperature, there is a change in the extreme temperature, there is a change in the amount of variability that we see in temperature, there is a change in the seasonality of temperature, there are changes in rainfall, there are changes in extreme events. We find more and more number of floods, more droughts, more storms, more fires - not only in a greater duration, but also in a greater intensity, or changes in carbon dioxide concentration in the atmosphere or in the oceans.

In the oceans when carbon dioxide gets dissolved it also results in changes in the pH - the water becomes more acidic.

There are changes in the ocean dynamics because of changes in the sea level. Why do we have a change in the sea level? Because more and more amount of ice is getting melted and this ice is adding to the water in the seas. And when the water is being heated up because of global warming it expands and so, we are seeing changes in the sea level. We are seeing changes in the marine currents.

So, all of these climate change components result in changes in the biological system - at the organismic level, population level, species level, community level, ecosystem level and even at the biome level. For instance we will start seeing changes in the natural selection and we will look at changes in natural selection and allelic diversity in a short while.

There are changes in mutation rates in different organisms because the mechanisms that are there to correct for mutations - they are hindered because of an increased temperature and because the animal is not that fit. There is change in the heterozygosity richness, there are changes in physiology, changes in fecundity. So, organisms will be having less or more number of offsprings. Organisms are changing their activity rates and rhythms - those organisms that earlier used to move in the known period - they are now avoiding the known period because its too hot.

There are changes in the species sex ratios, changes in disease susceptibility - especially because of a changed climate, now the organism is not that fit and when the immune system is down - when the organism is not that fit - it can very easily fall prey to diseases which is resulting in

changes in the survival of organisms. We are also seeing changes in the phenology. Now phenology refers to the timing of different processes. So, we are seeing changes in the arrival and departure times of different migrating species because the summers are coming earlier, they are lasting longer - the winters are coming late, and they end faster. There are changes in migration patterns. Because of changes in temperature we are seeing changes in budding and flowering of different organisms - different plants. If there are changes in the budding or flowering period, there are changes in migration, then it is also possible that there will be certain species that will not be getting sufficient food. Because in a number of cases the migration patterns are correlated with the presence of food in the other location.

Now if there is a species of bird for instance that is dependent on these flowers and if the birds have reached into the area, but the flowers have not bloomed - in that case the birds will not have sufficient food. So, changes in phenology are also leading to a large amount of extinctions.

There are changes in the growing season length. Those plants that grow in the summer season - they are now getting more time to grow; those plants that use the winter season - they now have a shorter growing period. There are changes in dispersals of hatchlings and fledglings; there are changes in hibernation. Now because of these we are also seeing changes in the population dynamics, the number of individuals that are recruited which means the number of offsprings that have been born and that are able to survive. Because of that if less number of individuals are getting recruited, less number of young ones are getting recruited - that changes the age structure, because now the population will be older population because you have less number of young ones. There are changes in sex ratio - especially in the case of reptiles because in a number of reptiles such as crocodiles - or in the case of tortoises, the sex selection is temperature dependent. So, if the temperature changes you will have a changed ratio of the number of males and females that are born.

We are seeing changes in abundance, we are seeing changes in distribution. Why changes in distribution? Because the habitat is changing. And why is the habitat changing? Because of changes in the growing season, changes in budding and flowering time, changes in hibernation. That is changing different habitats.

We are seeing changes in the range size, range localization, and we are seeing changes in the interspecific relationships. There is an uncoupling of a number of relationships such as those between the flowers and the insects. So, in the case of a number of flowers the pollination is done by, say, insects. Now if the flowers are blooming at a period when the insects have not yet arrived on the scene - because probably the insects have not come out of their eggs - in such a scenario there will be a decoupling because earlier the insects were getting food from the flowers and the flowers were getting pollinated by the insects. Now because there is a change in the timing the insects will not get sufficient food, the flowers will not be pollinated and so, this will result in a decimation of both of these species.

We are seeing new interactions that are coming - because whenever you have a change in timing then those species that are already present - there they will start to form a new relationship. Now that may have a positive consequence, but that can also have a negative consequence. So, for instance the invasive species are able to come up into newer areas much more easily because they are forming newer relationships and these invasive species are then decimating the local indigenous flora and fauna and they are establishing themselves - the local biodiversity is gone and it gets replaced by the invasive species. This is another change that we are observing.

There are changes in the community productivity - the amount of biomass that is being produced. We are seeing changes in the ecosystem services because the ecosystem composition is changing, the production is changing, the function is changing. And we are seeing changes in biodiversity.

Because we are seeing catastrophes at a much greater frequency, at a much greater intensity, there are changes in the resilience of different communities - there are changes in the eco types, we are seeing shifts in the distribution patterns, we are seeing more and more amount of desertification. So, there are a number of biological responses that we are also observing because of climate change.

And we have a pretty solid evidence that these anomalies are occurring because of changes in the climate or changes in the temperature. In the case of a number of species we have observed that the more is the temperature anomaly, the more is the phenological anomaly. And this is also manifesting in terms of say the amount of phytoplanktons that are there in water. With increased temperature the amount of phytoplankton in water is going down which will have an impact on the amount of productivity, that is there in this aquatic ecosystem.

We are seeing that the total biomass is going down as temperature increases. Certain species of zooplanktons - they increase in number or increase in concentration when the temperatures go up. Certain microorganisms increase in number. Now some of these microorganisms may even be pathogenic. So, we will start observing more and more number of diseases.

We are observing bleaching of corals. Corals are very important species in a number of ecosystems because they provide shelter to a number of other species. They are the keystone species - their importance is much greater than the numerical abundance. Now because of changing climate, because of acidification of water, because of increased temperatures and because of certain pathogens the corals are dying out. And this dying of corals is manifested in the form of lack of color. So, we are observing more and more amounts of coral bleaching.

We are observing that the ice cover near the poles is going down which is putting species like the polar bear in a much perilous state. Species of mangroves are dying out, species of kelps are dy-

ing out. All of these - the corals, the kelps, the mangroves and the ice - they are habitats that provide a living space to a number of organisms and when we are seeing these habitat level destructions, it means that a number of species are now under threat because of climate change.

We are seeing an increase in the invasion - and rise - of exotic species. In this curve you can see that over the years the number of frost days has gone down which means that the temperatures are rising up, at the same time the number of exotic species is going up. So, there could be a correlation between both of these.

We are observing rigorous responses in plants in the forest - we are seeing changes in the stand volume, changes in the annual increment that the forest is putting down, changes in the gross primary productivity, changes in carbon sequestration that has been done by the forest, and we are also seeing changes in a number of animals in terms of their health. Things such as climate change result in extremes of temperature which increases the chance of an animal getting the heat stroke. Climate change is leading to weather disasters. An increased frequency and an increased intensity of extreme weather events such as floods and fires increases the chances of animals drowning or animals suffering from dehydration or from gastrointestinal illnesses. Because in the case of a flood-like situation, the animals are forced to have dirty water which is resulting in a lot of trouble to animals. Climate change is also leading to ecological changes because of changes in the phenology, because of decoupling of pollination relationships between plants and animals - which is leading to changes in food availability.

If an animal gets less amount of food it will suffer from malnutrition - we will have cases of growth retardation, developmental delays. Similarly, because of changes in the phenology and because of changes in the range of different plants, we are seeing changes in allergen and mycotoxin exposure that the animals are suffering from. We are seeing more cases of allergies, cancers and birth defects - these ecological changes also increase the chances of exposure to infectious diseases - and a number of infectious diseases are also emerging anew.

We are also observing other changes. Every organism has a particular level of temperature that it can tolerate. There is a best temperature that the animal prefers - there is a tolerable temperature and if we go beyond the tolerable temperatures, the animals suffer from discomfort and may even perish.

Now, because of changing temperatures what is happening is that, we are observing a large number of local extinctions. If the temperature increases beyond the tolerable limit, then we will start seeing animals that are dying. So, there are local extinctions in the warm edge. And these extinctions have been predicted to increase with more and more amount of global warming. We are also observing changes in the spatial distribution of organisms - because suppose this is the equator and this is the north direction. As temperatures go up, more and more of these colder areas are now becoming warmer. These organisms that were living here, they will be able to occupy

these areas that were so far not being occupied because they were beyond the tolerable limits of these organisms. So, on the one hand the organisms will be dying in the warm end, on the other hand there will be an expansion in the cold edge. So, we are seeing changes in the spatial distributions, changes in the ranges of different organisms. A good example is the spread of insects in the mountains as the temperatures are going up.

As we move up the temperature goes down. There are a number of species of insects that are only able to tolerate the warmer conditions; they cannot tolerate the colder conditions. Because of that a number of species of insects are only localized in the lower height of the boundaries. Now as the temperatures are rising what is happening is that these cooler areas are also now becoming warmer. As temperatures rise, these insects - which were earlier only in the lower altitudes - they are now able to reach into the higher altitudes. So, we are observing changes in the spatial distribution of insects.

Also with increased amounts of climatic extremes, increased amounts of rains in certain areas, increased amount of flooding, we are also observing that insects are making use of these pools of water to increase their numbers - because they lay eggs in these waters. We are seeing changes in the vectorial capacity of mosquitoes or the ability of mosquitoes to transfer diseases - and we are seeing changes in the allele frequencies at the genetic level. A very good example here is the story of the Tawny owl.

The Tawny owl is a species of bird - it's an owl that is found in Europe. This bird is available in two colors - there is a lighter version which is grayish in color and there is a darker version which is brownish in color. In the areas where this bird lives the trees are generally covered with snow. When the trees are covered with snow - and snow is white in color, so the gray colored birds are able to hide in the snow. If there is say a rat here that one of these birds wants to catch and eat. In that case if it is a brown colored bird, then it will be very easily seen by the rat and this rat may try to hide whereas, if it is a gray colored bird then it camouflages so well that the prey is unable to observe this bird and it increases the chance of the bird getting a prey.

Because of this reason a majority of the birds are gray in color. Now the color of the bird is determined by the genes that the bird has - the allele frequencies that are there in the bird population. A majority of the birds are light in color and there are very few birds that are dark in color. Now, because of global warming what has happened is that, the snow is melting. So now, if we look at these birds that were gray in color now they are very easily seen in the backdrop of these trees and so, the advantage that they had in terms of color is now gone. Now if it is a light colored bird then the prey will very easily spot the bird, if it is a dark colored bird then it will be difficult for the prey to spot the bird. And so, how has nature responded? Or how has this species responded? Because these light colored birds are now less able to get to the food so, they have lost their fitness or they have greatly reduced their fitness whereas, the fitness of these birds has gone up and slowly we are seeing that more and more number of these birds are now in darker

shades - there are changes in the allele frequencies. So, we are seeing changes at the genetic level because of climate change. So, this is another thing that we are observing.

When we have such a huge amount of climate change what can we do about it? The kinds of responses that we can put up for conservation and to tackle climate change are divided into two categories: we can have mitigation or we can have adaptation.

Mitigation is defined as a human intervention to reduce the sources or enhance the sinks of greenhouse gases. The other way out is adaptation. Adaptation in a natural organic system is response to actual or expected climate stimuli or their effects which moderates harms or exploits the beneficial opportunities. It is an adjustment in the system - you are trying to adjust your lifestyle, you are trying to adjust your profession, you are trying to adjust the industry you are working in or you are trying to make adjustments in the ecosystems. So, it can be an adjustment in either the natural systems or in the human systems. And why are you doing these adjustments? In response to actual or expected climate stimuli or their effects.

You are making these adjustments so that you can respond to the climate change that is either actually happening or which is predicted. Adaptation is in response to actual climatic stimuli or expected climatic stimuli or their effects. The aim of adaptation is to moderate the harm. So, you are trying to reduce the harm or you are trying to exploit the beneficial opportunities that climate change may offer.

So, for instance, if you are living in an area that is extremely cold and you think that because of climate change - because of some amount of warming, now the climate will become a bit more pleasant in your area. That might result in the development of a new opportunity - probably tourists will now start coming to your area. And if you are making changes - if you are say developing infrastructure or if you are doing advertisement so that you can attract these tourists to make use of the beneficial opportunities - then you are doing adaptation.

So, the two responses to climate change that you normally make are either mitigation or adaptation. In the case of mitigation what happens is that, we ask what can we do to avoid climate change or to reduce the climate change. If the earth was going to raise its temperature by say 1.5 degrees can we bring it down to 1 degree, then we bring it down to 0.5 degrees? If we are doing that by either reducing the amount of greenhouse gases that will be emitted into the atmosphere or by trying to bring down the gases that have already been emitted, then we are doing mitigation. The other response is adaptation where you say that ok climate change is going to happen, and I cannot do anything about it, but is there anything that I can do to reduce my harm or to make use of the beneficial opportunities? If you have such a response then what you are doing is adaptation.

Often both of these strategies are needed together and they are used together. So, how do you de-

cide? What needs to be done? So, there is climate change - if you foresee that the impact is minimum or if you find that the impact is minimal then probably you do not need to do anything in that area.

But if the climate change is too much and you find or you predict that the limits are going to be exceeded then you have two options - you can either figure out if there is a way to mitigate the emissions or you can figure out that there is no way that mitigation is possible. If there is an option of mitigation that is available and you deploy it, then you may have a success or you may have a failure. If you are expecting that climate change will exceed the limits, will bring you too much of a harm, you try to mitigate the emissions and you get a success because of which the impact is now minimal. When that happens you do not need to do any other thing - you can sit back and relax, but if you get a failure - so you tried to mitigate the emissions, you tried to bring the levels of greenhouse gases down, but they resulted in a failure - you could not do anything - then you will decide that mitigation is now not possible which means that the only option that you have now is adaptation.

In the case of adaptation, we can adapt to a particular capacity. There is always an adaptive capacity of any system whether we talk about a natural system or whether we talk about manmade system, whether we talk about an industry or whether we talk about a profession, we can only adapt to a particular extent - adaptation is not infinite.

So, when you cannot mitigate the only option that is left is adaptation. Now, if you have an adaptive capacity that is sufficient to adapt - which means that suppose there is a society that has ample amount of resources and say can come up with an air conditioner in every home. Now air conditioner in this case will be an adaptation because it is not doing anything to reduce global warming, but it is helping people to live in this area which has heated up too much. So there could be certain societies that can do adaptation - there will be certain other societies that are probably the poor societies and they will not be able to bring about adaptation. If the adaptive capacity is sufficient then adaptation is possible. If the adaptive capacity is not sufficient then adaptation is not possible.

If the adaptation is not possible here again you have two options, you can either build up the capacity - so you build your adaptive capacity, you find out ways in which you can have more sources of energy, you can have more number of air conditioners, you try to increase your capacity of adaptation as a society and if you are able to do that then adaptation becomes possible.

So we reached to this point where mitigation was not possible. So, the first step is that if we can mitigate we will try to mitigate, but if we are not able to mitigate - if mitigation is not possible, then we will try to adapt, but then it is also possible that the adaptation is not possible - and it is not possible to build the capacity. Now that becomes an issue because you are neither able to mitigate , nor are you able to adapt.

In that case the only options are either to perish as a society or to look for some other ways of mitigation. So, what we find from this flowchart is that at all points of time we as a society need to think. If we can mitigate the emissions, we should try to act in that line; if mitigation is not possible or if we as a society fail to mitigate climate change then we could adapt, but it is also possible that if adaptation is not possible because we have a limited adaptive capacity as a society, then it is also possible that we will perish. So, these are the options that are there. Mitigation and adaptation both need to be tried. The first option is of course, mitigation. You try to ameliorate the climate change, but if that is not possible then as a society adaptation might be our only option.

So, what are the mitigation options that we have in the society? To reduce emissions we can come up with laws. For instance, the government might say that any vehicle that has a fuel efficiency less than a prescribed limit will no longer be permitted to be manufactured. In this case we are using a law to mitigate climate change by not allowing the production of those vehicles that are fuel inefficient or we may come up with a law that says that any person who is using electricity above a certain threshold will have to pay a penal rent. Here again we are talking about a law to incentivize people to cut down on their electricity consumption.

You will remember that incentives are what induce people to act in a certain way and law is a very powerful tool to induce activities that need to be promoted or to dis-induce those activities that need to be suppressed. So, the government may use laws to promote those mechanisms that reduce the emissions or the government may make use of laws to penalize those mechanisms that are leading to a large amount of emissions other options with us are use of green energy. Green energy - such as solar cells - they take off our dependence on the fossil fuels. If in place of using a thermal based power plant we have shifted to say solar power plants - in that case the emissions because of the burning of coal they will be gone.

So, we will be acting in a way to reduce the emission or REDD. REDD stands for Reducing Emissions from Deforestation and Forest Degradation which means that whenever there is deforestation that is a forest is getting cut and is getting destroyed or there is a degradation of forest which means that we are shifting from a dense forest to a moderately dense forest to an open forest probably to a no forest or a scrub forest. Now, when such a thing happens we say that there is a forest degradation. Now whenever there is deforestation or forest degradation there is emission of greenhouse gases because the carbon that was stored in the plant biomass that has now been released because when people cut these trees they will either burn them or they will convert them into furniture which will slowly and steadily again emit out the carbon.

Now when we have deforestation or forest degradation all of this carbon is getting released out. There is also another chunk of carbon which is there in the soil. So, the soil carbon gets released when you remove the tree cover and the carbon that is released is of a very significant quantity.

So, whenever there is deforestation or forest degradation there is an addition of greenhouse gases. If you prohibit or if you can prevent deforestation and forest degradation then you are reducing the amount of emissions that would have happened if there was a deforestation or forest degradation. So, REDD is another mitigation option - you are trying to reduce emissions from deforestation and forest degradation.

Other option that we have is to create sinks which are the mechanisms that are going to take greenhouse gases away from the atmosphere - things such as having more amount of afforestation. Planting more trees or going for artificial trees - artificial tree is nothing but a device that can mimic photosynthesis and try to capture carbon from the atmosphere. Now it is still in an experimental phase, but yes if the technology gets developed that can also be used as a mechanism. To create a space for carbon - we can try to do carbon sequestration in geological sites. Now, what is that? You make use of machines to capture the carbon from the atmosphere; we compress this carbon dioxide - probably react it with certain chemicals so that it gets fixed and then we store it in a geological site - probably you make use of an old mine and you put these chemicals or these this carbon dioxide in that area and we shut it off, so that the carbon dioxide that was there in the atmosphere is now no longer in the atmosphere - it has been kept closed in a geological facility. So, this is another way of creating a sink - carbon sequestration in a geological site. Or we can look at REDD plus. So, here REDD is reducing emissions from deforestation and forest degradation. When we say REDD plus what we do is we do conservation, sustainable management of forest, and enhancement of forest carbon stocks.

In the case of REDD plus what we are saying is that we are going to conserve the forest that we already have and at the same time we are going to perform a sustainable management of forest. In a sustainable management of forest the wood is removed from the forest, but it is removed in such a fashion that you always have trees that are absorbing carbon from the atmosphere. What it means is that if you have a forest and the forest only has those trees that have become very old - so they are no longer putting up any further growth in them. In that case they are not collecting or fixing the carbon dioxide that is there in the atmosphere - because if they were fixing the carbon dioxide then there would have been certain growth in their bodies, but they are so old that they are no longer putting up any increment.

So, in the case of REDD plus what we do is that we do a sustainable management of forest in which case we remove those trees - that is we cut down those trees - that are very old and plant a new tree in its place or plant several new trees in its place and the wood that has been removed from this old tree is processed in such a manner that the carbon will not be released back into the atmosphere for a very long period of time. So you process it and you use it to make certain goods that are long lasting that is you are not going to use this wood say for fuel wood or for the manufacturing of paper that has a short life, but you will probably use it to make certain furnitures that will last for several decades and in the place of this tree that was removed you plant several new trees so that you always have a young generation that is fixing the carbon dioxide that is there in

the atmosphere.

That is the sustainable management of forest. Through sustainable management of forest we are converting an old forest that was no longer putting up an increment, that was no longer doing carbon sequestration and perhaps was even emitting carbon - because the old trees were dying naturally and they were being acted upon by other organisms that were eating up those wood and were releasing the carbon back into the atmosphere. Here we are avoiding that and we are converting it into a sustainably managed forest where wood is extracted for a long term use and the old trees are replaced by younger crop that can do the carbon sequestration. So, that is sustainable management of forest.

Or we can look at opportunities where we can enhance the forest carbon stocks which means that if you already have a forest is there a way to increase the density of plants, so that you can have more amount of carbon that gets sequestered? Is there a possibility that apart from having trees you can also have certain undergrowth or say certain climbers - climbers and undergrowths are also plants - they will also be fixing carbon dioxide that is there in the atmosphere and storing them as biomass. So, is there a way in which we can enhance the amount of carbon that is there in the forest? Can we do something about the amount of carbon that is stored in the soils - it gets increased? When we look at these opportunities - conservation, sustainable management and enhancement of forest carbon stocks - we are talking about creation of sinks through REDD plus. So, this is also another mitigation option that we have.

In the case of adaptation, these are the elements of adaptation: You begin by observing the climatic variables such as temperature or the amount of rainfall that you have in your area - you look start to look at non climatic variables such as if there is an invasive alien species of plant or animal that is coming into your area and through these observations you make an assessment. What will be the impact of climate in your area? How vulnerable is your country or your society or your community to the impacts of these climate changes? And once you make this assessment that yes the community is vulnerable you make a plan. You could make a plan such that you are trying to remove the invasive alien species of plants that are coming into your area and will have an impact on agriculture. So, you say that we are going to cut out all of these plants that are coming into our area then we implement the plan, you actually take help of people and you actually cut the plants and then you do a checking - did you achieve the objectives? Were you able to control these plants?

Now it is possible that you were able to control the invasive alien species or it is also possible that the roots that got left behind - they sprang up new shoots in the rainy season. In that case you will have to make certain adjustment, which means that we are going to uproot the roots - you are going to uproot the plant completely and for that you make the new plan and you do the cycle again and again. This is the Deming cycle: plan do check act, and in between you make use of observations; you make a continuous assessment.

Now adaptation is of three different kinds. It can be anticipatory that is proactive or it can be reactive. Anticipatory adaptation is an adaptation that is done before the negative consequences are being felt by your community. A reactive adaptation is done once the negative impacts are already being seen. For instance, if you anticipate that you are going to have droughts in your area and you start to come up with new irrigation mechanisms - you are doing an anticipatory adaptation. On the other hand, once you are already seeing a drought and you install more pumps you are doing the reactive adaptation.

Adaptations can be spontaneous or they can be planned. A spontaneous adaptation is say increasing the speed of your fan because you are feeling warmer. A planned adaptation could be a plan - to say remove the invasive alien species or to set up new hospitals because you are seeing a rise in the number of diseases.

Or the adaptation can be private or public that is done at the individual or community level or at the government level.

And in adaptation we generally do three things: we try to create a resistance to change. So, if we expect that there will be more number of forest fires, we try to reduce the effect of fires. In the case of insects and diseases you try to have a better protection against them - you remove the invasives, you do a resistance breeding so that the plants or animals in your area are more capable of tolerating the drought or flood situations or increase temperatures. So, that is creating a resistance to change.

Another option is promoting a resilience to change. The resilience means that if there is a climate change and there is a negative influence if later on you are able to bring back the effects of the climate change you should have a capacity to bring your system back to normal - things such as surplus seed banking. So, in this case what we are doing is that we are creating a seed bank so that we have the seeds ready whenever the temperatures come back to normal - whenever the climate comes back to normal, we can make use of these seeds and recreate the whole ecosystem. Or intensive management during establishment - here establishment means establishment of trees or promotion of biodiversity rich ecosystems because biodiversity rich ecosystems are more capable to come back to normal whenever the situations are brought back or the third adaptation option is to enable a response to change. Now, how do you enable response to change? You assist natural adaptations and transitions - assisted migration to newer areas. So, what we are saying here is that because of changing climate we expected that this that we will have a range expansion in this area and we will have an extinction in this area. So, in the case of assisted migration what you do is that, it is possible that the dispersion in this area will be very slow - so you actually take a few individuals and you bring them to this area. So, that is an assisted migration in which case you are trying to enable the forest or the ecosystem to respond to change. We try to increase redundancy; you manage for asynchrony. So, when you are expecting that your flowers

will not be pollinated because there is a change in the timing of flowers and the insects. Can you manage for that? And you bring in say an insect species from some other area that will be able to pollinate your plants in this particular point of time or you can try to look at the past spread of different forest. And you can try to establish them now. Or you can try to promote connected landscapes so that the animals are able to move to the other areas. In this case we are enabling the forest or the ecosystem to respond to changes. So, these are the three main adaptation options: you create a resistance to change, you promote resilience to change and you enable the forest to respond to changes.

Now whenever we are doing adaptation it is important to note that there is an adaptive capacity: the ability of a system to adjust to climate change including variability and extremes to moderate potential damages, to take advantage of opportunities or to talk to the consequences. There is a capacity whether we talk about the forest, whether we talk about the nation, whether we talk about the community - there is a capacity to adapt. If you try to do an adaptation that is greater than the capacity, then probably you will bring harm to the system and in that case we will say that we have gone through a maladaptation - any change in the natural or human systems that inadvertently increases the vulnerability to climatic stimuli, an adaptation that does not succeed in reducing vulnerability, but increases it instead.

So, for instance, a good example is that you tried to do an adaptation by installing an air conditioner into every home in your country and in running of those air conditioners you release so much amount of carbon dioxide - because of burning coal or say natural gas - that the climate change increased even further and because of which there is a catastrophic collapse of the community - everybody perishes out then we will say that this is a maladaptation. So maladaptation is any changes in natural or human systems that inadvertently increase the vulnerability to climatic stimuli or an adaptation that does not succeed in reducing the vulnerability, but increases the vulnerability - that is maladaptation.

Now, as before we can relate climate change and the responses to the ten principles of economics. People and society face tradeoffs. Here the tradeoff is whether you want to have more and more resources now or whether you want to survive in the future, whether you want to have more and more electricity now by burning fossil fuels or do you want to forgo the impacts of climate change. So, there are always tradeoffs - these tradeoffs lead to cost - what you give up to get something. So, if you want your children and your grandchildren to live in a planet that is still safe to live - that is not seeing very extreme climatic events, then probably you will have to give up on certain amounts of comforts.

So, tradeoffs lead to cost. People respond to incentives which means that if we can incentivize the use of green technology or if we can disincentivize, the generation or emission of greenhouse gases, then probably people will respond to them and these incentives could mean things as simple as taxes and subsidies. So, if the airline tickets cost more because of an added tax say because

of greenhouse gas emissions, then probably less people will be interested to use the airline and more people will, say, shift to other modes of transportation. And when we talk about incentives, the governments can sometimes improve market outcomes because the government has a legitimized power to make changes.

So climate change is something that is happening today, climate change is something that is because of the misguided actions of humans. We have the option to mitigate, we have the options of adaptation, but then if we want to actually perform significant and successful mitigation and adaptation, we will have to make use of the principles of economics to incentivize people towards the right path. So, that is all for today.

Thank you for your attention. Jai Hind!

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Module 3
Modern impacts necessitating conservation
Lecture 2
Plastics

Namaste! We carry forward our discussion on the modern impacts necessitating conservation and in this lecture we will have a look at plastics. Now plastics need no introduction - they are synthetic materials made from a wide range of organic polymers such as polyethylene, polyvinyl fluoride, nylon etc., that can be moulded into shape when soft and then set into a rigid or slightly elastic form.

So, what are the characteristics of plastics? They are synthetic materials. Synthetic material means that it is a manmade material. It is made from a wide range of organic polymers. So, it is not a homogeneous substance, but quite a large variety of chemicals can be formulated into plastics. Good examples are polyethylene, polyvinyl chloride, nylon and so on.

Now, the important characteristic of plastics is that they can be moulded into a shape when they are soft, which permits us to manufacture different kinds of substances using plastic materials. So, you can mould plastic into say a bottle, you can mould it into a pen, you can mould it into a chair and so on.

So, they have this important property that they can be moulded into a shape when they are soft and then set into a rigid or slightly elastic. So, it is no wonder that plastics surround us. In any room where you are sitting, if you look around you will find a number of particles that are made out of plastics and plastics surround us because they have some very good properties. They are cheap to manufacture, they are water resistant, they are light in weight, they are very strong and so on.

So, let us have a look at a short history of plastics. How did we come into this civilization of plastics? The earliest plastics in the terms of the synthetic material was made in 1600 B.C. when Mesoamericans processed natural rubber into a plastic. So, the natural rubber was converted into a plastic and this plastic was used as a ball. So, they used to play with this ball and the history of plastics is as old as 1600 B.C.

Then in the 19th century, polystyrene and polyvinyl chloride were invented and the 20th century saw the creation of a large number of plastics. In 1909 we had Bakelite that was used in commercial products. In 1926 polyvinyl chloride was commercialized and so it entered into the homes of a number of people. In 1933 Saran was invented. In 1937 Polyurethane foam was invented. In 1938 Teflon was invented. In 1939 we had Nylon and neoprene. In 1941 we had Polyester and PET and then a major change came in world war 2 when metals became scarcer and plastics started being widely manufactured to replace them.

Here again there was a trade-off - because people did not have access to metals and metals were very largely required for a number of things, so people started shifting towards plastics. This was a big trade-off during the 2nd world war. In 1951 high density polyethylene and polypropylene were invented. In 1954 Styrofoam was invented. In 1979 the plastic production in the United States exceeded the steel production

What we are seeing here is that the generation of plastics started and then it moved with a bang and then very soon it started growing exponentially. Plastic production is currently increasing at 5 percent per year and we see that a large quantity of plastics - more than 30 million tons is being produced every year.

We can relate this to the 10 principles of economics. A country's standard of living depends on its productivity. So, every country wants to manufacture more and more of the goods. And plastic again is one good that can be manufactured, that can be sold and that can be used in a number of ways.

So, a number of countries started to produce plastic. It was easy to produce. The raw materials that it required were easily accessible: petroleum and petroleum products, they are easily available, they are cheaply available and the technology to make plastics is also very simple. And so the plastics were produced in a very large quantity and soon we had plastic all over - all around us.

Now, the question is where does all this plastic go ? Plastics like every other material have a life. So, you take a bag of polythene, you buy some vegetables in it, you bring it to your home, you are going to use the vegetables, but then what do you do with the plastic?

Plastics because they are too cheaply manufactured and because of their good properties - they are manufactured in a large quantity. So, we have a large generation of plastic that is occurring in this world, but most of these plastics have a very short period of use . A number of plastics that are used in the manufacturing of bags - you bring your materials to your home in that bag and now you are not going to use this bag again.

So, what happens to all of these plastics? We use plastic disposable pens once we have used

these pens once they have stopped writing, what do you do with the pen? You throw them out into a dustbin. What happens after that?

In a number of biodegradable materials such as wood, once you have used a material once it has lost its properties once it is no longer useful if you put it out there in the environment there will be some organisms that will be acting on this wood and converting it back into the elements that find in the wood, mostly carbon hydrogen and oxygen - which is the basic premise on which our bio geochemical cycles work.

But in the case of plastics not many organisms can eat up a plastic and even if they eat a plastic very few organisms are able to digest this plastic. Now, the good properties of plastic that it is resistant to the impact of water it is resistant to the impact of chemicals and it is a strong substance also, means that it is resistant to the impact of enzymes in the bodies of organisms and that it is going to persist in the environment for a very long period of time.

So, what happens to these plastics? Well we have heard that plastics can be reused and recycled, but the fact remains that a very small percentage of plastics are ever reused or recycled. If we go back to this curve - this curve shows us the generation of plastics and this bottom curve shows us the recovery of plastics.

Recovery includes recycling. So, the amount of plastics that is being recycled is a very small fraction of the total amount of plastics that is being generated every year. So, a very small portion can be reused or recycled, but what happens to the rest of the plastic?

Well, some of the plastics are burnt, burning is an important method that is used in waste management because once you burn something you convert a fraction of it into gases that get released into the atmosphere and some portion that remains is of a smaller size and so can be handled easily.

So, for instance if you have large quantities of wood and you did not want to throw them out because you do not have access to landfills you can always burn the wood and if you burn the wood it will be broken down and it will be oxidized back into carbon dioxide and water, the substances that actually made the wood during the process of photosynthesis.

And the small amount of ash that remains will be rich in the nutrients, that is, like nitrogen and phosphorus and potassium. And this ash will be of a very small volume. It will be a very small mass and you can put this ash to some plant and this plant will use it back again because it is full of nutrients.

So, when you burn the wood the largest portion is burnt in the form of carbon dioxide and water and some portion that remains as ash can be used as a fertilizer for other plants. But, what hap-

pens when you burn plastics? When you burn plastics you release not just carbon dioxide in water, but a number of other noxious chemicals such as dioxins.

Now, dioxins are chemicals that can very easily impact the development of a young child or the development of a fetus. They are extremely dangerous chemicals and when plastics are burned a large fraction of plastics also release dioxins.

Then a major portion of plastics is also put into the landfills. Landfill is a simple option if you do not know what to do with these plastics. What you do is that you just take it to an area and you dump it in that area. Landfill typically is a depression in the ground that is being filled with these plastics, but then remember that they are generating plastics at an ever increasing amount.

We have a large quantum of plastics that is being generated and we are now running out of space in the landfill. Now, remember again that plastics are very light materials, now if it is a light material it also means that it is going to occupy much greater volume as compared to a denser material. So, landfills quickly get filled up with plastics.

So, what happens? You are only reusing and recycling a very small fraction of plastics, when plastics are burnt they reduce dioxin. So, burning is not a good option, landfills are an option, but then we are running out of landfills.

What actually happens is that quite a lot of plastics are getting released into the environment. And even when you are putting plastics into the landfills it also gets released into the environment because some organisms might go to these plastics because it is all full of rubbish and you can have animals such as rats that are being that are living on this rubbish and so, when a predator comes and attacks a rat to eat it it is also possible that it may also take away some of the plastics.

Also when it rains the plastics being lightweight materials they can float in water. And so if you have a landfill and if there is a heavy downpour and if the landfill is full to its brim it is possible that some of the plastics will start floating in water and they will move away. They will move together with the rain water in the form of surface flow and they will ultimately reach into the water bodies. So, they can reach into your ponds, they can reach into your lakes, they can reach into the rivers and ultimately they will also reach into the oceans.

Now the situation is that we have a material that is lightweight, strong, resistant to chemicals and this material is now spread everywhere. It is there on the land it is also there in all the water bodies, some portion of it may even sink. Now, if you ever wanted to collect all of this plastic bag, how are you going to do that? So, plastics become a menace because they are not being disposed of properly.

What happens to these plastics once they reach the oceans and the seas? 15 percent of these plastics float on the surface, 15 percent of the plastics wash to the shores and as much as 70 percent of the plastics sink to the ocean bottom .

What we are observing here is that some fraction keeps on floating because of its light weight; some fraction is washed off to the beaches. Now beaches have sand. People like to go to beaches, but now our beaches are also getting filled up with plastics because the ocean waves are bringing these plastics to the beaches. And then a major fraction of the plastics as much as 70 percent it sinks to the bottom. And we will look at how a lightweight material is able to sink to the bottom in the next few slides.

But in brief what happens is that if you have a plastic and if the container gets filled up with water or gets filled up with some other substance which is heavy in weight then the plastic might sink down. And also in a number of cases the plastics get eaten up by animals and the animals dive down, so the plastics also dive down together with them.

And the third way is that from the plastics when they get degraded they form smaller particles and these smaller particles remain suspended for a very long period of time, but then ultimately they also come down.

So, as much as 70 percent of the plastics sink to the bottom once they have reached the oceans. So, this is what it looks like. So, you have this water body and you can observe these plastics that are floating on top. Now, these plastics comprise a majority of single use plastics. So, these bottles were not meant to be reused and so people use them and then they throw them into a dustbin from where it goes to a rubbish heap and from there it has reached into a water body.

Or plastics can come to the shore and when they come to the shore some of the animals may start interacting with these plastics. And at the same time it also makes it very dirty . Or you can find plastics on the seabed. Here you can see this person is picking up certain plastics that are there on the seabed.

Plastics are classified on the basis of their size into 3 categories. We have macro debris, we have meso debris and we have micro debris. Macro means big in size so any plastic that is greater than 20 millimetre in size we will call it a macro debris. 20 millimetre is 2 centimetre. Anything that is more than this big we will call it macro debris.

Ghost nets amongst these are a major concern and we will have a look at ghost nets in a short while. Meso debris: meso means in between so it is a debris that has an in between size and we call 5 to 20 millimetre size plastics as meso debris. And they are dominated by nurdles; nurdles are resin granules that are intermediates in the plastic production.

What that means is that when plastics are produced chemically: plastics are polymers - so we start with monomers, we polymerize those monomers and then we get to a polymer. Now, this polymer is then formed in the form of small resin particles - they are like this big. And these resin particles are then sold off to other companies that are going to make use of these plastics.

Now, remember that when we started with plastics; plastics have the property that they can be moulded into a shape when they are soft. What these companies do is that they buy these nurdles then they heat them up so that they become soft and then these nurdles are processed to make the plastic products that the companies are manufacturing.

So, these nurdles which are like this big - we will call them meso debris. And in a number of cases they reach into the oceans because when they are being transported on a ship and if there is an accident if these nurdles are just released because one of the containers broke then these nurdles will directly reach into the oceans.

The third category is the micro debris micro means small. So, these are debris of small size less than 5 millimetre in size and they are often formed through fragmentation of macro or meso debris and they also consist of plastics rubber particles as are found in face wash and other cosmetic products.

What happens is that when we have the macro debris and we have the meso debris and when these plastics are acted upon by the UV rays of the sun or they are acted upon by the oxygen that is there in the air or because of mechanical action because if there is a plastic piece that is floating on water and together with the waves it can get thrashed with rocks or 2 plastic pieces can bump into each other and once that happens these plastics may break into smaller fragments.

The macro debris and the meso debris will break into smaller particles and ultimately they will form the micro debris. But, micro debris also comprises certain small particles that are manufactured that way less than 5 millimetres in size for use and cosmetics. So, these are the three size classifications of plastics: macro debris greater than 2 centimetre in size, micro debris less than 5 millimetre in size and meso debris everything in between.

When we look at the production of these smaller fragments the synthetic polymers have a number of things together with them. If we look at any plastic container such as this bottle of water. Now, this is plastic, but it also has a number of other constituents, so it has a stabilizer, it has certain fillers and it has a plasticizer.

These chemicals are added to the polymer which is the plastic to improve the properties. So, the stabilizer will stabilize this material. You would also want to add certain other substances that make it look much more transparent or add colors to it and so on.

When the large sized plastics reach into the atmosphere, when they reach into the environment they have all these stabilizers, fillers, extenders and other additives that are together with the plastic. When they reach into the environment they are acted upon by a number of things light acts on and especially the UV rays of the light are able to break the bonds.

The UV rays have high energy and they are able to break the bonds in these plastics. The plastics are polymers. If you break the bonds you will convert them into oligomers or into the monomers, and in this process the plastic piece will start to fragment into smaller sized particles.

A good example is if you take this bottle and if you keep it on your rooftop for a few months you will start seeing that it will slowly turn whitish in color and then it will start to become more and more brittle. And after a while it will start converting into smaller fragments.

The other thing that acts is oxygen. Oxygen is able to oxidize some of these substances: not just the polymer or the oligomers that are being formed, but also the stabilizers, fillers, extenders and other additives. When these chemicals get oxidized then they lose their properties and so the plastic becomes more and more brittle. And some biotech organisms such as microbes and worms can also act on these plastics.

And then we have a number of reactions. We have the absorption of light, especially this UV light and when the light is absorbed you can have a photolytic reaction.

Photolytic: photo means light and lysis is breakdown. This is a reaction in which there is a breakdown because of the light. In certain other conditions when light is absorbed it also leads to the heating up of the material, and when there is heating up of the plastic and if there is a differential heating then that will also lead to some amount of expansion and contraction which may lead to some more amount of fragmentation in these plastic particles. Because of the presence of oxygen and because of the presence of UV light you also have the formation of radicals.

Radicals also accelerate the process of degradation of these plastics. Or you can have enzymatic degradation when the plastics are acted upon by biological entities such as microbes and worms. And because of all these reactions: you have oxidation and you have scission. Scission is again a process of breaking down or cutting down. So, oxidation and scission reactions will lead to discoloration loss of mechanical integrity, strength and impact properties of the plastics and slowly and steadily the plastics will start breaking into smaller fragments.

Is this breaking good or bad? Well it depends. In certain cases you want to fragment these plastics into smaller particles so that you can dump them into a landfill in a much concentrated manner, but in a number of other cases it accelerates the process of these plastics being eaten. Because this large sized plastic bottle - there are very few organisms that will be able to eat this plastic, but then if I have a small piece of plastic then it is possible that a fish or a bird may just

confuse this material with food and might eat it.

So, these smaller fragments accelerate the process of plastics entering into the biosphere. This is how the decomposition occurs. When the plastics are acted upon by light water, oxygen and so on. We will see that in a number of these rubbish deep heaps you will find that you have a small piece of plastic film, now this is 1 millimetre so this is around say 2.5 or 3 millimetres, which means that it has now reached into the stage of being a micro debris.

Then you have these small foam particles. If you look at a big size Styrofoam we will call it a micro debris, but then if you look at the smaller pieces that come out and especially when they are acted upon and broken down further they will become into micro debris.

We have all these small fragments of plastics that are coming from a line: a line means that it is coming from a rope, then you also have these pellets or beads and especially those that are used in the cosmetic industry as exfoliators. You find all these different kinds of plastics in debris, you will find fibers, you will find film and so on. And these smaller fragments will be formed in the water body; it is also possible that they may start to aggregate together.

When they when these small particles aggregate together they form a middle sized particle that has a much greater density and in that case this fragment together in the form of the the aggregate it will start coming down in the ocean waters and slowly and steadily it will reach into the ocean flow and we call such things as marine snow.

Now, it is also possible that these smaller particles get eaten up by certain organisms and they are ejected out in the form of faeces. And all these processes the formation of the ecocorona or formation of faeces or or formation of marine snow they all make it possible for these smaller fragments to start going down to the ocean bottom.

When you have all these plastics what is the impact on the environment? And especially what is the impact on the different organisms that are there in the environment? What is the impact on the biodiversity that we have? Let us have a look at that. The first thing that can occur with plastics is that it can be eaten and in a number of cases the plastic bags are confused by a number of organisms as food.

If you look at these plastic bags they look very similar to jellyfishes and if there is an animal that naturally feeds on a jellyfish it may confuse these plastics as jellyfish and it will eat these plastics. Now, plastics because they are strong substances which are able to resist the impact of most of the chemicals so these plastics will not be digested in the body of these organisms that eat them.

What will happen to these plastics in the body? These plastics may enter into the alimentary

canal these plastics may then start to block some portion of the alimentary canal. It is possible that these bags of plastics reach into the intestines and then they just remain there in the intestine and so there is a blockage that has been done.

Now, once that happens the animal will be unable to eat any food because there is a blockage in its alimentary canal and if that happens the animal will slowly and steadily start to die because it is not getting sufficient nutrition. This is an image of an albatross chick, now albatrosses are large sized birds and these birds also show a very great amount of parental care.

So, what happens in the case of an albatross is that the parents go out into the sea to catch fish and bring them to the baby. Now, if there is a piece of plastic that is floating on top of the water in the ocean it is possible for these birds to confuse this plastic as a fish. So, the parents will catch this piece of plastic, bring it to the chick and feed it to the chick.

And here we can observe that this was a chick whose body is all full of plastics. So, this is the amount of plastics that its parents had brought to it and fed it. And because of these plastics its alimentary canal got choked and this small bird died. So, albatrosses are facing a big danger because of these plastics that are floating on top of the water.

But we also observe ingestion in all sorts of organisms with their big or small. So, here is a blue colored microfiber. Here if you look at the size this much is 200 microns. This fiber would be like 500 micrometers that is half of a millimetre. And the thickness is a few microns and this sea pen polyp is a creature that lives in the oceans and here we can find that in this creature as well we are finding a plastic microfiber.

Now, remember that plastics are synthetic substances and before they were invented there were no plastics. All the other things that nature was making were biodegradable, but these plastics are not. So, we can observe plastics in large animals, we can observe plastics in small animals and we can even observe plastic in microscopic animals such as these zooplanktons.

Now, these green colored substances are micro plastics and we can observe that we have these micro plastics that have even impacted the microscopic organisms such as the zooplanktons. Ingestion is one big way in which plastics can impact the wildlife. Another way they impact biodiversity and wildlife is through entanglement, even smothering. So, what happens is that the plastics that are left out so they can be thrown out or probably they get out because of some accidents and these plastics can act as ghost nets.

Now, here we can observe that this is a fishing net that was there in the water body and the fishing net is meant to capture animals, it is very good at capturing animals and even when this fishing net is thrown into the ocean probably because its useful life was gone probably because it had lost its strength. So, the fisherman had just thrown it into the water body, but then this ghost

net was still capable of catching animals.

And here we can see that this turtle has been caught in this ghost net and when this turtle is caught, now this turtle is unable to move, this turtle is unable to feed and then slowly ends and steadily it will die out of starvation.

A number of other animals also require that they should be able to come to the surface, dive down, come to the surface for oxygen, dive down for food and so on. So, if these animals get entrapped when they are down at the bottom they will die out of asphyxiation, because they will not be able to come to the surface and breathe. If they get trapped on the surface they will not be able to dive to get their food. So, entanglement is also a major way in which plastics are decimating our biodiversity.

Another way is the example of the seal. Now, what happened was that this seal when it was a small pup, it got entangled with this piece of plastic. Now, plastics are very strong substances. This seal was unable to take it out, and then when this seal started to grow in size the plastic started to cut into its body. And here we can see that this plastic is cutting into the body of the seal.

And we can observe these things in a number of animals. I have seen some monkeys in the forest that have plastic that is tied across their waist and those monkeys are unable to feed because this plastic is pressing against their bodies. So, entanglement is also another way in which plastics decimate our biodiversity.

Another way is through the release of persistent bio accumulative toxic substances. Now, you will remember that plastics have these chemical stabilizers, fillers, extenders and other additives to improve their properties. Now, once you have released a plastic into the environment and this plastic is now floating on the surface of a water body these substances that were added into the plastic they can slowly get released out.

Now, these substances were added to the plastic to improve the properties and in a number of cases there was no consideration of how toxic these chemicals are when they are eaten up by organisms. And in a number of cases we find that these plasticizers are extremely toxic substances. So, if you release these plastics into a water body and these substances are slowly getting released into the water body, it is making the water body more and more toxic. It is leading to a degradation of the habitat that was earlier a prescribed habitat.

Another way in which plastics impact biodiversity is through the persistent bio accumulative and toxic substances. Now, bio accumulative means that these substances will accumulate in the bodies of organisms typically in the fat layer that is there in the bodies. These substances, because they are organic chemicals, can easily get dissolved in fat and so they will accumulate in the fat

bodies.

They are also persistent which means that they remain for a very long period of time. Which means that when these animals die these chemicals do not disintegrate, they remain persistent and so they will kill one animal because of their toxicity and when this animal dies these chemicals because they are still undegraded they again come back into the environment. And then they still maintain their toxicity levels and they still can kill some other organism.

So, these are persistent bio accumulative toxic substances. Good examples include bisphenol A which is an endocrine disruptor. Now bisphenol A is used as a plasticizer, when we say plasticizer if we look at this bottle it is able to maintain a certain amount of plasticity when you press it and it comes back into the original shape. It is soft and it is transparent.

So, chemicals such as bisphenol A are able to give these properties, but then bisphenol A is also an endocrine disruptor which means that it acts as a hormone, when it gets into the body and it disrupts the functioning of the normal hormones that are there in the bodies of the organism. So, this plasticizer when it is released into the environment can hamper the hormones that are there in the bodies of different organisms.

Another example of these chemicals is the brominated flame retardants that are used in the number of plastics. Now, brominated means that they are full of bromine and these are flame retardants that are typically used in things such as sofas or chairs. So, if there is a fire then plastics because they are made from petroleum and because they are hydrocarbons they can burn very easily.

And so to prevent accidents by law it is mandated that a number of these long term usage plastics should have brominated flame retardants. But, then these brominated flame retardants even though they are able to stop fires, but when these plastics are then thrown back into the environment and when these come out when they reach out they are also accumulative toxins. So, this is also another way in which plastics hamper biodiversity.

Another way is the accumulation and concentration of hydrophobic toxins. What does that mean? Plastics are hydrophobic substances. Hydro is water, phobic is fear of, so if you take a piece of plastic, if you add water to it then water does not wet the surface of the plastic, which tells us that it is a hydrophobic substance.

Now, if in water you add certain hydrophobic substances they tend to clump together. A good example is that if you take water and if you add a few drops of oil all of this oil will come together in the form of a layer. Now, when there is a piece of plastic that is out there in the water then all other hydrophobic substances will get attracted to this piece of plastic and they will accumulate on the surface of this plastic, because this particle was fearful of water this plastic is fear-

ful of water.

When both of these come together then at least this much part of the plastic as well as this particle is now not exposed to water. So, because of which these substances clump together.

Once that happens if you look at this water it has certain hydrophobic substances, probably toxic substances, but then they are there in a low concentration. But, if you put this piece of plastic and all these hydrophobic substances come and stick to the surface it means that now there is a much greater concentration of these hydrophobic toxic substances on the surface of this plastic. And we have seen before that plastics can get eaten up by different organisms both big and small, and once these organisms eat these plastics all of these hydrophobic toxins reach into the bodies of these organisms in a very high concentration.

This aids in the poisoning of our biodiversity. So, this is another way in which plastics impact our biodiversity. Then they also have the potential to alter habitats and behaviours. Habitat as we have seen is the natural home or abode of an organism and plastics have the potential to change the homes of animals. And once their homes are changed their behaviours also change.

For instance this is a crab that lives on the beaches and we have seen before that as much as 15 percent of the plastics get washed to the beaches. So, now the habitat of this hermit crab has plastics, earlier these hermit crabs did not ever observe a plastic, but now their habitats have these plastic pieces.

Now hermit crabs have this property that they make use of different shells of organisms as their protection layers. If you watch a hermit crab in most of the situations it would make use of the shell of certain molest animals and it will get inside these shells and these shells will provide protection to the hermit crab.

Now, what we are observing here is that this hermit crab is using a piece of plastic as its protection. Now, this is not a natural behaviour, this is an artificial behaviour which is there because this hermit crab is now finding quite a huge amount of plastics in its natural habitat. So, plastics have the ability to alter habitats and behaviours and this is also another way in which plastics impact wildlife.

This picture is showing us that there is a seahorse that is sticking to this piece of ear bud. Now, this is not a natural behaviour because in a pristine ocean, we do not have ear buds but now that there are ear buds in this portion the animals behaviour is changing. In a number of cases we find that animals are reaching into these rubbish dumps in the search of prey such as rats and now they are getting more and more exposed to these plastics.

We have the natural habitat of the hyena that has been disturbed, but at the same time the behav-

iour of these hyenas is also now getting disturbed. Because now they will look at plastic as something very natural and probably they will interact with these plastics. Earlier if it was a pristine environment and if a hyena found a red colored piece of plastic probably it would run away, but now it has been so much accustomed to these plastics then it might even try to eat up a piece of plastic. So, plastics have the ability to alter habitats and behaviours.

This is an image from Manas tiger reserve and this is the dung of rhinoceros, and what we are finding is that inside the dung we are finding pieces of plastic. This is a plastic bag, a blue colored plastic bag. So, even in a tiger reserve we are finding plastics have entered and animals are eating up these plastics.

Another way in which plastics impact biodiversity is by facilitating the dispersal and transport of invasive species. The dispersal as well as the transport and especially of invasive species. Now, what does that mean? A number of plastics are light in weight, they have a less density so they float on top of water.

Now, if an organism needs to move from one place to another it may just use this piece of plastic as a boat and together with this plastic it will move to some other location. Now, earlier the organisms did not have this option the only options that were there were say things like wood or a small piece of twig or a branch.

Now, those being biodegradable the organisms were unable to move to very far distances, but now that we have plastic in such huge quantities available to these animals these plastics are also acting as boats and rafts for a number of organisms for them and facilitating their movement.

Now, what happens is that a number of invasive species are also able to use these boats and rafts; plastic boats and rafts to reach other places and then they start to colonize the other places. And once that happens the local biodiversity may get decimated because the invasive species are able to out-compete the local species and then they establish themselves and they wipe off the local indigenous biodiversity.

So, this is also another way in which plastics are impacting our biodiversity. This paper showed us the incidence of rafting on marine debris by different taxonomic groups. And what are all the things? So, one is that you can find that different kinds of organisms are using plastics.

Sponges cnidarians worms sea spiders crustaceans molluscs bryozoans so many different kinds of organisms are making use of plastics. And they are using quite different varieties of plastic, ropes and netting fishing materials intact items packaging fragments and microplastics.

And if we have a look at the natural materials which are there in these colored forms and the artificial plastics that are being used by these different organisms. So, say in the case of crustaceans

this much amount of movement is happening because of the plastics and this much amount of movement is probably a natural movement.

So, we find that plastics have overwhelmed the system and they are increasingly being used as a means of transportation by different varieties of organisms and this is also increasing the possibility that a number of invasive species will be able to move from one place to another. And once that happens it will be a sad day for biodiversity.

Then, even micro plastics can influence the complete hierarchy. So, we can find that the microplastics are able to cause different impacts at different levels of the hierarchy. At the subcellular level we find that microplastics can influence enzyme activity; they can influence gene expression; they can influence oxidative damage. At the level of cells they can lead to apoptosis now apoptosis is programmed in death. So, microplastics may result in the death of different cells; it may hamper the membrane stability and may impact the phagocytic response.

Now, phagocytosis is the process by which a cell is able to eat. Now, if a cell starts to eat these microplastics then probably they will also impact the phagocytic response of different cells. At the level of organs they impact the histopathology, the metabolic demand of the organism and the energetic reserves that are there, because in the organs when plastics and special microplastics get accumulated then the energetic reserves are depleted.

At the level of individuals they may result in mortality; especially if an organism eats too much of these plastics and they impact a vital organ. Or they can impact the ingestion rates or the growth of the individual. At the level of population because the individuals are now not that fit and their organs are not working properly that will have an impact on the fecundity.

It may influence offspring viability because we have seen the case of this albatross in which the offspring viability was impacted because of the presence of plastics. And even and in the case of smaller organisms the micro plastics will also play a very similar role.

Now, the the saddest part here is that when this chick died because its body was all full and blocked by these plastics the body of the of this albatross chick because it is made out of biodegradable materials it will slowly degrade, but then these plastics because they are non biodegradable they remain persistent.

So, what will happen is that with the next range the these plastics will be able to come back they will again come back into the oceans and probably they will be picked up by some other albatross. So, this process goes on and on and so these plastics may result in the deaths of quite a large number of organisms. At the level of the ecosystem we have seen that plastics influence the behaviour of different organisms.

We have seen the image of this hermit crab which is now using this plastic or we have seen that a seahorse is using this plastic. Now, what happens is that if a particular species becomes too much acclimatized with these plastics it may change its behaviour to such an extent that certain other species may also get impacted.

So, for example, to take a simple example we can consider the pollination that is done by different birds and different insects. Now, suppose you have quite a large number of red colored or bright colored plastics that are strewn around on a field and suppose insects must take them for flowers and they land on these plastics and they spend all their time on these plastics in search of food.

So, they are not going to the flowers and in that case the pollination that these insects were doing in the flowers will get impacted. And so, because of the change in the behaviour of the bees and the insects the species of plants will also get impacted. So, at the ecosystem level as well we can observe different detrimental effects that are being brought about by these plastics.

So, how can we help? Well the good old technique is reduce reuse and recycle, reduce the amount of plastics that you use on a daily basis. As far as possible you reuse the components that are made out of plastics. So, if possible do not throw this bottle once you have used the water you probably fill this bottle again and you use it for some more time.

So, reduction in the use of plastics, reuse of plastics and recycling of plastics such as in this recycling facility are very important. But then if you want that people should go for reduction, reuse or recycling what needs to be done as we have seen in the principles of economics incentives need to be provided.

You need to induce people so that they shift away from plastics and they reduce reuse and recycle plastics as much as possible. And so economics plays a very important role here. Economics made it possible for plastics to come up in such a big way because they increased the living standards of different people, but then we can also make use of principles of economics to tackle this problem. Or we can induce people to go for lifestyle changes, use glasses in place of the straws or go for alternative materials such as bioplastics.

So, these days we also have biodegradable plastics that are made from natural products that have very similar properties. So, they are like this film of the bioplastic: it is completely transparent, it is flexible, you can mould it, you can bend it. And the strength of these bioplastics is similar to or greater than the strength of the common plastic such as the low density polyethylene. Or if we go for a bacterial cellulose composite of this plastic it is even greater than that of the high density polyethylene.

So, we have alternatives available with us, but then how do you induce people to shift into bio-

plastics? Again we have to make use of incentives. So, at all points of conservation we need to correlate the 10 principles of economics. Now, here the principles that are the most important are people and society face tradeoffs. Now, here the trade off is earlier. We shifted to plastics because the trade off was during World War 2, we did not have access to metal and so we shifted to plastics as a trade off.

But then once we shifted to plastics we improved their properties to such an extent that now plastics have become the mainstay and after a while they even overcame the amount of production of steel or of another material. So, there is always a trade off and this trade off has made it possible for people to shift to plastics.

But now again we are facing other trade offs. Now, the trade offers that we do not have sufficient landfills, our biodiversity is going down and these plastics are also leading to a large amount of pollution, they are leading to a large amount of filth and our beaches are dirty.

So, the use of this plastic started with a trade off because we did not have metals and the disuse of plastics is also being facilitated by a trade off. Because you have two options you can either use plastics and suffer all these consequences or you can shift away from plastics and save yourself from these consequences.

So, everywhere there is a trade off, and these trade offs lead to cost. Now, there is a short term cost and there is a long term cost. Now, in the short term manufacturing of plastics is cheaper so people shifted to plastics, but then the long term cost or the life cycle cost the cost of picking up all these filths and the cost of processing these filths is too large. The cost that we are suffering in terms of the loss of biodiversity is too large. So, this is an important economic principle that can save us from plastics; but we will have to emphasize the negative cost that we are facing because of the use of plastics.

Another important principle is that people respond to incentives. So, how do you incentivize people to reduce reuse and recycle? Well in a number of cases people have come up with an alternative that if there is a vending machine and if you put a used bottle into this machine you will get certain money out of it. So, this money is an incentive to promote people not to throw the plastic out into the litter, but to bring it to a machine where it can be easily recycled.

Another alternative incentive that has been formulated is provisioning of subsidies in the manufacturing of biodegradable plastics. Or provisioning of taxes in the case of manufacturing of petroleum based plastics. So, people respond to incentives and so if we want people to move away from these petroleum based plastics we will have to impose certain costs. And if you want people to shift towards biodegradable plastics or to reduce reuse or recycle we will have to facilitate that with certain incentives and here also comes the role of the governments.

Because these taxations and subsidies in most cases are given by the government they are implemented by the government. So, governments can improve market outcomes and in this case the market outcome in the case of plastics is not the most efficient one.

Because if the government did not intervene then there is a huge externality with the use of plastics because if I use plastic I carry all the benefit of the usage, but the cost of its littering the cost of biodiversity loss or the cost of making the surroundings dirty is born not just by me, but by everybody else.

So, it makes it possible for me to use the plastics more and more because I am not paying the cost, but then if the government comes up and says that ok we need to internalize these externalities through taxations and through subsidies . So, if somebody is using plastics we are going to tax it more, if somebody is using biodegradable plastic we are going to provide him or her a subsidy. If these things come up then probably the market will shift to a more optimum level.

So, the government can sometimes improve market outcomes and also a country's standard of living depends on its productivity. So, earlier we saw that the levels of plastics increased so much the production increased so much because most of the countries were emphasizing that we need to produce more and more.

Now, today as well we need to have more and more of different products, but then if we can emphasize that these products not only need to be cheap, but they also need to be environmentally friendly then probably we can shift away from the nuances of these plastics.

So, that is all for today. Thank you for your attention. Jai Hind!

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Module 3
Modern impacts necessitating conservation
Lecture 3
Oil spills and mining

Namaste!

We move forward with our discussion on the Modern Impacts that Necessitate conservation and in this lecture, we will have a look at Oil Spills and Mining . Now, before we proceed , it is important to note that disturbances can have different impacts on an ecosystem.

And the amount of impact or the quantum of impact depends on how large the disturbance is; it also depends on what is the state of the ecosystem when the disturbance came and it also depends on how frequently we are getting this disturbance. So, for instance if there is a normal community and here on the x y-axis, we are representing the state of the community; on the x-axis we are representing time.

If there is a normal community; there would be some ups and downs in the community state. So, there are some normal variations which are the natural variations that we observe in any community; none of the, none of the biological communities are a static community, there is always some level of dynamism.

Some populations would increase, some populations would decrease; there would be some changes in different parameters. But there is a level of natural variation, which is there and discover showing that this is the normal level of variation. And then if there is a single large infrequent disturbance; LID stands for a Large Infrequent Disturbance.

There is this disturbance at this point in time t and the state of the community shifts from normal to an altered state. So, from this normal curve, it comes down. But then because the community was a novel community; it would have some level of resistance and also some level of resilience. After this disturbance is gone, the community would try to come back to its normal state. And which is what we are seeing here; there is this period of recovery and in this period of recovery, the community is trying to move back to its normal state. And after this recovery period, we find that there is this community which has come back to the state, where it was before the large infrequent disturbance.

In short, if there is a normal community and there is a large infrequent disturbance, the community will shift from a normal state to an altered state and after a time period for recovery, it will come back to normal. Of course, if the large infrequent disturbance is so large that the community has ceased to exist; then that is another matter .

But in most of the situations we observe that, after a while the community does prompt back. Now, what happens if you have another large infrequent disturbance? So, we are seeing a normal community here and then there is this large infrequent disturbance; because of it, it has come to an altered state.

Now, the community is trying to move back towards normalcy; but then you get another large infrequent disturbance. What happens then? So, in a number of cases it is possible that, because of multiple disturbances, the community is now no longer able to come back to the normal state. And in that case, the community will remain at this altered state for quite a period of time.

And it is also possible that the community never comes back to its normal state . So, the moral of the story is that, if you have a normal community; it would be able to withstand a single or maybe just a few large infrequent disturbances, but if you give it a disturbance again and again and again, it is quite possible that the community will change completely.

It will become an altered community; it will have a very different set of species that are able to live in that area or probably it will turn into an area which cannot support any further species. But this is what happens when the community is there in a normal state.

What happens if the community is already disturbed from the beginning? So, you have a community which is not normal, it is not altered; but it is somewhere in between and it is continuing like this and then you get a large infrequent disturbance , the community shifts to an altered state and now it is no longer able to come back .

Now, what can be the reasons for such disturbance to the community? Well, there could be many reasons, such as pollution. So, there is a community; so, you are talking about a forest for instance and in this forest, there is such a huge level of pollution that most of the animals are already safe.

Or let us consider a lake and in this lake, if we are dumping industrial effluents or some municipal waste; then there is so much level of disturbance that the lake community or the lake ecosystem is already in a very disturbed state. And if you have an ecosystem of a community which is already disturbed, you give it any further disturbance and it might not be able to come back to a natural state .

Now, in this context, what are the large infrequent disturbances? Some very common large infrequent disturbances are things, such as fires such as a forest fire. So, if you have a forest and you get a forest fire, large number of organisms spirit; but if you have a certain patch of forest that remains, then the organisms that remain in that area they will be able to procreate, they will increase in their populations, the trees that are there they would give off seeds and these seeds would then repopulate the whole of the forest.

These animals would then repopulate the whole of the forest. So, in the natural circumstance if you have a single forest fire, it is ok; the forest community will be able to come back. But then if you have a forest fire again and again and again and especially if it is not a natural forest fire, if it is an anthropogenic forest fire.

Now, in our country we know that as much as 95 percent of the forest fires are of human origin . Now, if that is the situation in a number of areas, then it is possible that we are shifting the community from a natural state to an altered state . Another LID is a storm or tsunami . Now, if there

is a large storm or if there is a tsunami; then we will also observe that quite a number of individuals, quite a number of species perished in large storms or tsunamis.

But if it is only a single incidence; then probably the community will come back, if sufficient numbers of individuals of the species remain in that area . Another large infrequent disturbance is an oil spill or things, such as climatic extremes, in excess of floods, in excess of drought.

These are all disturbances that are large in nature and at the same time they are infrequent; we do not get a drought every year or things such as heavy pollution, especially one that is due to mining. Now, in the case of mining, a very huge quantum of toxic materials gets dumped and that leads to a very large infrequent disturbance in the form of pollution .

Remember that when we are talking about multiple disturbances, it is not necessary that they should be of the same category. So, it is possible that the first disturbance was say a forest fire and the second disturbance was a tsunami. So, any of these large infrequent disturbances can play a role in bringing the community or the ecosystem to an altered state.

And if you have multiple of these, then the community of the ecosystem will permanently come to an alternate state and it will never be able to bounce back . So when we talk about a disturbed community , such that the community did not start from a normal; but it started from somewhere between normal and altered, then these are the examples of disturbances.

A disturbed community could be one that is already diseased. So, if there is a disease in a community, the individuals are already weak; they will not be able to come back to resilience. Or a community that is weed infested , especially one that is infested with an invasive alien species, such as lantana.

If you have a forest that is all covered with lantana; then it is already in a somewhat disturbed state, because the seeds of different trees are unable to reach the ground. And even if they reach the ground, they find it difficult to germinate, because of allelopathic factors. And even if they are able to germinate, then they are unable to grow; because they are all covered with lantana, they are not getting sufficient sunlight.

Now, in such a situation, if there is a forest fire; then we would have a situation where a large number of trees get perished and also because we do not have a sufficient number of seeds that are there buried in the ground, because of the lantana; then it is possible that the community will permanently come to an altered state.

Or a community that is facing competition from livestock, especially for grazing activities or a community that is already suffering from pollutants, such as a lake in which we are dumping industrial effluent or municipal waste or a community that is already facing climatic changes, such as global warming . So, all these are examples of disturbed communities and disturbed communities are much more susceptible to the disturbances and if you disturb a disturbed community further; then it is quite possible that the community will never be able to come back to a normal state .

Now, in this lecture, we will concentrate on one such large infrequent disturbance, which is the oil spills. Oil spill is defined as the release of liquid petroleum hydrocarbons into the environment. Now, as we all know, the liquid petroleum hydrocarbon; petroleum the word root is oleum is oil and petro is rocks.

So, this is rock oil. Essentially petroleum is made from the remains of animals that were buried millions of years back and because of intense heat and pressure inside the earth, slowly and steadily they got converted into petroleum. These are here. We drill holes into the earth and we extract these oils.

And after refining, we get things such as petrol or diesel or kerosene or LPG and so on. Now, if this liquid petroleum is deep inside the earth, if it comes to the surface, either naturally or because of some accidents or intentionally; but if it comes to the surface and if it gets released into the environment, then we say that we have a situation of an oil spill.

Now, this oil spill can occur on land or it can occur in water. On land a classical example is the Kuwaiti oil lakes that were formed during Iraq's invasion of Kuwait. So, in this case the oil gets spilled over the land and it forms lakes. An example of the marine oil spill is the deep water horizon accident of 2010.

In the case of a marine oil spill, the oil gets released into the water; it may come to the surface, it may form an oil slick, it may spread to a large area or it is also possible that a portion of it gets dissolved or it gets sedimented. So, according to the location, we have terrestrial oil spills and marine oil spills.

This is how a terrestrial oil spill looks like. So, this is an oil lake in Kuwait and you can see that this large area of earth is inundated with oil. So, these are the oil pools that were formed. This is the deep water horizon oil spill and we can find that in this marine environment, you have a large amount of oil that is there on the surface .

Now, on the basis of how it got spilled, we have three different categories of oil spills; we can have natural oil spills, such as the oil spills in the Gulf of Mexico. Now, because the oil is found deep inside the earth, it is possible that some amount of it gets leaked. And this leaking oil will be known as a natural oil spill. An accidental oil spill is when nobody wanted to or to spill the oil; but then just because of an accident, it got spilled out into the environment, such as the deep water horizon accident.

And we can also have intentional oil spills, such as the Gulf war oil spill, in which case the armies may try in the process of destroying the oil wells, they may spill out the oil. So, it was done intentionally; the intention was to destroy the oil wells and the effect was that the oil got spilled.

Now, this is an example of a natural oil spill. So, this is the Gulf of Mexico and we can see that these lines are the oil that is getting spilled out naturally. When oil gets spilled, quite a large amount of hydrocarbon comes out into the environment. So, what is a hydrocarbon?

A hydrocarbon is an organic compound consisting entirely of hydrogen and carbon and they form a major chunk of the petroleum oil. So, petroleum oil is composed of a large variety of hydrocarbons, which are organic compounds made entirely out of hydrogen and carbon.

So, hydrocarbon; hydro is hydrogen and carbon is carbon. So, these are some common hydrocarbons that you find in oil; we find alkanes, cycloalkanes and also organic compounds, such as benzene, toluene, naphthalene, anthracene and so on . Now, on the basis of their specific weights are classified into groups 1 to 5; the group 1 comprises very low specific gravity hydrocarbons, such as kerosene.

Now, very low specific gravity means that, when these oils get released into a water environment, say a marine environment or a lake environment; then these are going to float on the surface of water. Group 5 comprises very high specific gravity oils, such as bitumen.

And here the specific gravity is greater than 1; which means that when they get released into the environment, then they are going to sink. If they come into a water body, they will sink to the bottom. And group 2, 3 and 4 are there in between. So, this classification based on specific gravity is useful when discussing the fate of oil and the persistence of the oil spills.

Now, hydrocarbons are also classified in one other way, which is on the basis of how they are formed. So, the first classification is petrogenic; petro means rock, and genics genesis is formation. So, petrogenic means hydrocarbons that are formed out of rocks.

So, they are derived directly from the mineral oils; of course we are not saying that there are rocks that get converted into hydrocarbons, but then these are the hydrocarbons that are directly derived from petroleum, that is the rock oil. So, these are petrogenic. Another category is pyrogenic; pyro means heat and genesis is formation. So, these are those hydrocarbons that are formed through heating, which are derived from incomplete burning of mineral oils.

The third category is biogenic; bio is life and genesis is formation. So, these are those hydrocarbons, whose formation is related to some sort of processing in life or in a living organism. So, these are derived from biological processes that are acting on mineral oils. So, what are these kinds of processes? What is the fate of oil in the marine ecosystem?

When oil gets released into the marine ecosystem, some part of it, especially the one that has low density or low specific gravity that will come to the surface; whereas the other portion that is of a greater density that will sink down in the form of sediments. So, the first thing is that we find some portion floats and the other portion sinks. A third portion may even get dissolved in water. So, there could be certain compounds in the oil that get dissolved in water. Also we can have some amount of dispersion. Now, in the case of dispersion, we can have very small particles that remain suspended in the water. So, and when you have this layer that has come to the top, we can have some amount that gets evaporated especially due to heat.

There will be some portion that gets evaporated, some other portion may be reacted upon; because of air and because of light, in a process that is known as photo oxidation, and most of the oil will spread. So, when it spreads, it may even get into a beach, in which case we say that it has stranded into a beach or it can spread out.

There is also the process of emulsification; in the process of emulsification, the oil reacts with certain other compounds and becomes emulsified, which means that it becomes more and more dispersed in the water. Then I mean it is there on the surface and also inside the marine environment, it can interact with living organisms.

Now, if there are certain organisms, such as say a dolphin that comes to the surface for breathing or a bird that comes to the surface to catch a fish; then this oil may result in coating of their bodies, some portion may even be eaten or dropped by these animals. There will be these processes of coating and injection.

And finally, the oils that remain in the marine environment, some portion of it may get degraded by the living organisms and some other portion may get accumulated into their bodies in the

process that is known as bioaccumulation. When the oil spills interact with the organisms, it can have several impacts on the ecosystem.

When the oil gets coated upon the bodies of the organisms; it may result in physical smothering, which will reduce the ability of the organism to move, to feed and also there will be a loss of thermoregulation, which means that the organism will not be able to maintain its own body temperature, so it may die out of hypothermia or hyper or hyperthermia.

Also upon coating, there will be some amount of hydrocarbons that get absorbed through inhalation of volatile hydrocarbons. So, they are coming in through the air passage. So, the animal is breathing these oils and the volatile components are getting into the body of the animal through the air passages and some of these hydrocarbons may result in toxicity to the animal.

Another portion may get absorbed through the skin and with the mucous membranes. Again there might be some level of toxicity, because of this absorption. Then we had seen that some portion of this oil gets dissolved and the portion that gets dissolved may get absorbed to the skin or it may get absorbed to the food and in both of these cases also, there will be some amount of toxicity.

Now, there are several factors that influence the quantum of impact that the oil will have on these organisms. So, there are factors such as seasonality, the breeding season. So, if the oil spill occurs in a breeding season; then it is the season where the organisms need more food, because they are preparing to produce the next generation.

If it happens during the breeding season; then the quantum of impact on the ecosystem will be much greater or if there are eggs or juveniles that are present. So, if the parents get to the marine environment to catch a fish. So, suppose there is a bird that has laid eggs and one of the partners goes to the marine environment to catch a fish and its body gets covered with oil.

Once it comes back and once it sits on the egg; then it is possible that the egg will also get covered with oil. When that happens; then because there is a chick that is developing inside the egg, it will also get impacted. Or if there are juveniles; because we have seen in a number of cases that, very young or very old individuals are much greater impacted by any of these disturbances.

If you have juveniles; then the oil spill will have a disproportionate negative impact on the species. Then it also depends on whether the species is playing a key role in the ecosystem. So, if there is an impact on keystone species, such as mangrove; then the overall impact of oil spill on the ecosystem will be much greater.

Now, what is a keystone species? A keystone species is one that has a function in the ecosystem that is disproportionate to its actual numerical abundance. So, for instance if you consider an ecosystem and there are a few mangrove trees in that ecosystem; the roots of the mangroves will be providing shelter to n number of species of the marine environment.

Fishes will be using the roots to lay their eggs, so that the eggs are protected from the predators. The frogs will be using this area; the reptiles will be using this area. And the branches and the leaves of the mangrove are also used as food by a number of organisms; the branches are also used by different birds for their personal and boosting behavior.

Now, if mangroves get impacted because of the oil; then it will result in an impact on all of these different categories of organism. So, if the species that gets impacted is a keystone species, then

the overall impact of the ecosystem will be much clearer. Then lifestyle factors also play a role. So, animals with a long life span and especially those that have a k selected reproductive strategy are more impacted.

Now, what does that, what is k selected? Now, in a number of organisms we find that there are two major sorts of reproduction strategies ; the first is known as an r selection or a rate dependent selection. So, what happens in the case of an r selected species, such as mosquitoes.

Every generation will have a very large number of mosquitoes; the parent mosquitoes will not take care of the offsprings and there will be a large mortality in every generation. But still because so many large number of mosquitoes have been formed, they have been produced. So, even if a majority of them die off; the few that remain will lay so many numbers of eggs that the species will continue.

So, this is in r selected species. And if because of oil spill there is an impact on r selected species, the impact will be much lesser; because even if a few individuals remain in this species, the species will continue. On the other hand there are certain other species that are constant selected or k selected, such as elephants .

Now, in the case of an elephant, each litter only has a single offspring . So, in any birth you will only find a single calf. Now, this single calf requires quite a lot of support from its parents. So, the parents will have to provide it with food; the parents will have to protect it, the parents will have to train it.

And it will spend a very long period of time with its parents and ultimately when it becomes mature, it will have secure maturity at a very late age and when it also gives rise to its offsprings in every batch, there will be only a single elephant that gets spawned.

This is a k-selected species. The k-selected species emphasizes parental care and it emphasizes having less number of offspring .

Now, in the marine environment, there will be a number of fishes that are r selected; because each generation will be having say hundreds of eggs or say thousands of eggs.

But then there are also species such as whales or dolphins that are k selected; because they only give rise to a single offspring and they do a lot of parental care. Now, if a species is k selected, then the impact of oil spill, oil spill will be much greater; because a few individuals that will remain after being impacted from the oil spill, they will not be sufficient to continue the species, because they in any case will be having just a single offspring.

The lifestyle factors also determine what is the impact of oil spills on the organisms. Another factor is the health and condition of the organisms; if there are organisms that are already stressed, because of some disease or if they are migrating, then the impact is much greater.

And because of these factors we connect two terms with the impact; the first is vulnerability , vulnerability describes the likelihood that a resource will be exposed to oil. And the second term is sensitivity, which assumes that the resource is exposed to oil and then describes the relative effect of that exposure.

For instance a deep water coral; because it is deep inside the water is not quite vulnerable to a surface oil spill, because the surface oil spill comes to the surface and so an organism that lives here is not that much vulnerable, because it is not getting exposed. But it is possible that this or-

ganism, while not very vulnerable, is sensitive.

A deep water coral may be sensitive, so that if it ever gets exposed to even a small amount of oil; the impact will be much greater. So, you can have some certain species that are vulnerable. So, the species that come to the surface, such as dolphins, are much more vulnerable than deep sea species.

And there are certain species that are sensitive, such as the corals and there are certain other species that are less sensitive. Also when we talk about the oil spill, one major impact is toxicity; toxicity is the potential or capacity of a material to have adverse effects on living organisms.

When we say that oil is toxic; we mean that it has an adverse effect on living organisms. And this toxicity may be acute toxicity or chronic toxicity; acute toxicity involves harmful effects in an organism through a single or a short-term exposure whereas, chronic toxicity is the ability of a substance or mixture of substances to have harmful effects over an extended period, usually upon repeated or continuous exposure, sometimes lasting for the entire life of the exposed organism.

Acute means something that acts in a short period of time. So, an organism gets exposed to oil and there is an adverse impact right away, then we will call it an acute toxicity. But if there is an organism that gets exposed to oil, probably in a much lesser concentration. So, when we talked about the portion of the oil that gets dissolved in the water.

What we are talking about is that, there is a portion that gets dissolved. Now, there are organisms that are living in the middle or they are living in the bottom. So, they are getting exposed to a very small amount of oil that was dissolved in the water. So, they are getting an exposure of a very small quantity over a prolonged period of time.

Now, this will also result in certain toxicity. And in this case, we will call it a chronic toxicity. And especially when we talk about deep sea organisms such as corals or when we talk about octopus; then the chronic toxicity is much more important than acute toxicity, but when we talk about those organisms that come to the surface, such as dolphins or the birds that come to the that do fishing and then come to and then come in to direct contact with the oil, in those cases active toxicity is much more important.

Then we also define the term exposure; exposure is the combination of the duration of exposure to the chemical and the concentration of the chemical, duration and concentration. Now, why is exposure an important term? Well, it is because, if there is an organism that is getting exposed to a very concentrated form of oil, such as an organism that has come to the surface for breathing and it is completely covered with the oil.

Then it is receiving the oil in a very concentrated format; it is receiving with roughly pure oil. So, in that case the impact will be large. On the other hand, if there is an organism that gets oil in lesser concentration; but it gets oil for a very prolonged period of time. So, the concentration is less, but duration is large; then also we will find that the impact will be much greater.

Exposure tries to join both of these things together; the concentration of the toxic substance and the exposure or the time period for which the organism gets exposed to this toxic substance.

A combination of both of these is known as exposure. And when we talk about exposure, we also talk about the exposure routes, which is the way the organism is exposed to the substance which can include ingestion, which is the organism is eating the oil directly or it is getting the oil

through its food or absorption through the gills or through contact with skin.

And we also define magnitude; the magnitude of a toxic substance depends on the sensitivity of the organism to the chemicals and is also a function of the concentration and the duration that is the exposure. So, essentially what we are saying is that, if you have an organism that is exposed for a very less, to a very less concentration for a very less period of time and is also very less sensitive; in that case the magnitude of impact will be less.

But if the exposure is medium and the sensitivity is high or the exposure is large and the sensitivity is high; then the magnitude of impact of oil will be much greater . And when the impact is large, then we may even see lethal effect; lethality means death of the organism.

So, you have an organism that is exposed to a substantial period of time itself at sufficient concentration and the organism is also sensitive; then it is possible that the animal will or the organism will die, in which case we will say that the oil is having a lethal impact on that organism.

But we can also have sub-lethal effects, which do not result in a death; but they result in a reduction of biological function or health, such as the ability to grow, ability to reproduce or the condition of the skin. Now, whenever we find an oil spill, the lethal effects are much more pronounced and they are much easier to quantify; but the sub lethal effects take a huge quantum of time to manifest themselves.

And in a number of cases, we may not know even after the passage of a few years or a few decades about the complete impacts of oil spills that were there in different categories of organisms; which is why it is always prudent to avoid oil spills as far as possible and to manage them as soon as possible.

Now, we also define bioavailability, which is the extent to which a chemical is available for uptake into the organism; and in the case of oil spills, it is closely related to the display of toxicity and the rate of biodegradation. So, bioavailability is the extent to which the chemical is available for uptake.

Now, if the substance is bio-available, which means the oil has been spilled out and so is now available for uptake; then we may observe bio accumulation. Now, in bioaccumulation, the organism absorbs the toxic substance through the roots of exposure and it absorbs it into its tissues at a rate, which is greater than the rate at which the substance is lost from the body.

It means that, whenever the organism is taking oil through one of its exposure root; the organism will be processing this oil in its body to remove its deleterious or harmful impacts. So, there will be some amount of processing that happens in the level and then it will also be released through the kidneys.

Now, if the rate at which the organism is getting the oil is greater than the rate at which the oil is removed from the body; then we will have a net accumulation of oil in the body of the organism and this is known as bioaccumulation. And we also observe in a number of cases bio-magnification or bio-amplification

Now, bio-amplification or bio-magnification is the increasing concentration of a substance, such as a toxic chemical in the tissues of tolerant organisms at successively higher levels in a food chain. So, what it is saying is that, if there is bioaccumulation. So, say the oil gets stored in the lipid tissues of the body.

So, the organism that is lower in the food chain, such as planktons, they will have a lesser concentration of oil in their bodies; but those organisms that eat these planktons, they will be getting the oil that is there stored in the bodies of so many planktons.

If we say consider a zoo plankton that is eating up the phytoplanktons; the concentration of oil in the body of zooplanktons will be greater. And it will be further greater in the case of a fish that is eating of the zooplanktons and even further in the case of a fish that is eating up these fishes that were eating the zoo planktons. So, as we move up and up the food chain, the concentration of the toxic chemicals, in this case the chemicals from the oil it goes on increasing.

And we have demonstrated evidence of biomagnification especially in the case of chemicals such as DDD. And you can observe that, if the concentration is in water it is as low as 0.01 ppm; the planktons have 5 ppm, the fish have 4 to 300 ppm and the fish eating birds have 1600 to 2500 ppm.

Now, the important thing here is that, the planktons may not be impacted by such a low dose of DDD in their body; 5 ppm is a very small dose. But at this dose of 1600 to 2500 ppm; these birds will start showing symptoms and impacts of DDD in their body. So, biomagnification results in a greater concentration of the toxic chemical in the bodies which results in a much greater impact of the toxic chemical in the bodies of these organisms that are higher up in the future.

We can also quantify the impacts on different animals. So, the planktons are sensitive and the oils may result in acute chronic and sub-lethal effects. However, they recover quickly, because they have short generation times. But the seabed life, it gets ecologically significant concentrations of dissolved or dispersed oil.

So, it is not getting exposed to the soil to the oil directly; because it is not there on the surface, but being in the seabed, it is getting dissolved or dispersed oil, but the impact is rarely below 10 meters. The subsea blowouts on that on the other hand, now here we are talking about the natural oil spill; so the subsea blowouts may have a higher potential for seabed impacts and deep water and sedimented hydrocarbons may also pose a risk to the bottom dwellers.

If you remember, here we said that a portion of the oil gets sedimented and when it gets sedimented; then the impact on this life on the seabed is much greater. Then in the case of fish, we see acute chronic and sub-lethal effects and from the point of view of fisheries industries, we also see a phenomenon that is known as tainting.

Now, tainting means that these hydrocarbons even in very low concentrations can be tasted or smelt in the meat and when that happens, then people do not eat those fishes. And so, the industry suffers a lot, especially economically; because the consumers no longer prefer these specials. In the case of marine mammals that need to surface periodically for air, they get exposed in very high concentrations of oil. There is soiling of fur that impairs insulation and thermo regulation and also water repellence. The cleaning of fur when the animal tries to lick its body to clean it, then it may result in ingestion into the body, smothering of airways may also occur.

In the case of marine reptiles, that need to surface periodically for air, again there is exposure to higher concentrations of oil. Smothering of air which may occur and a seasonality of nesting and egg laying behaviours may increase the magnitude of impact. Now, here we are talking about marine reptiles, such as turtles. So, if it is the season of turtles laying their eggs and there is an

oil spill; then it will have a very tragic consequence on the turtle populations.

In the case of birds, physical oiling of their feathers may cause hypothermia; because it results in a loss of thermoregulation, it may also lead to a reduced ability to move, because their feathers are soiled; a reduced ability to feed, because they have ingested these toxic chemicals. Injection may occur through preening.

Now, preening again is the behavior of birds in which they are trying to clean their feathers or consumption of contaminated food, especially in the fishes. And transfer of oil to eggs or the young ones may reduce the survival of the next generation. In the case of shoreline and coastal habitats, the seaweeds are much better protected from oil impacts due to their mucus coating that resists the oil.

But the mangroves, which are keystone species; they can get killed by viscous oil that covers their pneumatophores. Pneumatophores are special adaptations, in which case the roots go against the gravity and come up for air and if these get blocked, then the plant will not get air. Burrowing crabs may get killed when their burrows are penetrated.

And so, it is important that we reduce the impacts of oil as soon as possible. Now, in reducing the impacts, the first thing is cleaning; cleaning is defined as the return to a level of petroleum hydrocarbons that has no detectable impact on the function of the ecosystem. So, in the case of cleaning what we are doing is that, we are reducing the concentration of these oils that have been spilled to such a level that they no longer pose a risk to the ecosystem.

And we will look at the methods of cleaning in a short while. The second thing that we need to ensure is a recovery; the recovery of an ecosystem is characterized by the establishment of a biological community, in which plants and animals characteristics of the community are present and are functioning normally.

What we are saying is that, in the cleaning operation, we will reduce the oil, we will remove the oil; but then because the oil already has had certain impacts on the ecosystem, we will ensure that the ecosystem is also able to recover back. Now, how do we ensure that it recovers back? If there are certain species that have become locally extinct, we may try to bring them from other areas and repopulate this area or we may try to ensure that there are no further disturbances to this area.

So, recovery operations also play a key role. Now, in cleaning operations, the first thing is containing and scooping. Now, in the case of container and scoop operation; we use booms to contain a spill and a skimmer to collect the oil from the surface. So, because a majority of the oil comes to the surface; so we can contain this oil by using serpent surface structures that are known as booms. And once the oil is contained, then it can be scooped using the skimmer.

The second operation is burning, in which case the oil is ignited on the site. The third is dispersal using chemical dispersants that break the oil into droplets and that this leads to emulsification and facilitates natural biodegradation. And a number of these dispersants are detergents and nothing else, but detergents.

Now, in the case of a detergent, it has a hydrophilic head and a hydrophobic tail. And so, when there is an oil droplet, it will be surrounded by these detergent structures to form a missile. Now, in the case of a missile, all these tales are pointing towards the oil droplet and all the heads are

outside.

This ensures that this oil droplet remains in the droplet form and it is able to disperse off. And because it is small in size; so it can be acted upon by a number of organisms, especially micro-organisms that can easily break it down .

Or in certain cases, we just leave it as such; because even addition of dispersants or detergents can have a negative impact. And if you have a very small amount of oil spill, then it is also prudent to just let nature act; because there are so many organisms that will be acting upon this oil.

So, it can be left as such for nature to take care of or we may make use of biological agents and fertilizers; which means that we can add the microorganisms or we can add nitrogen and phosphorus that promote their growth. So, if you have more microorganisms that are acting on the oil, then the oil will get cleaned up faster. So, this is the idea behind the use of biological agents.

Now, similar to an oil spill, another major large infrequent disturbance is mining. And mining has several impacts on the ecosystem, such as deforestation. So, this is an area in Balaghat district of Madhya Pradesh in the year 2006 and then when mining occurred, this is the result. So, you can observe that all of these forests, these thick forests, are now gone.

Mining results in deforestation, it results in soil erosion; because now all of the soil is exposed. And so, when it rains, then the soil will get washed away; if there are heavy winds, the soil will be removed. So, it increases soil erosion. Mining results in the creation of sinkholes; because now this area has been mined and in that case, it results in the formation of certain sinks in this area.

Now, these sinks can accumulate water in them and they may accelerate the process of weathering of the calcium rich rocks in that area, which will result in the formation of sinkholes. It also results in water pollution, especially in the case of tailings dams. So, tailings dams are those areas where the effluents are stored. So, in the case of this Balaghat mine, this is a tailings dam. So, the water that is rich in copper and other toxic elements is stored in this area.

And if you look at these trees that were there in 2006; in 2018 all of these trees are gone, because this is toxic water. Nobody is coming here to cut these trees; but the trees die themselves, because the water is toxic. So, it results in water pollution, there is a loss of habitats; direct loss, because the trees are gone and indirect loss because of pollution.

Now, this is an example of Ok Tedi Mine, which is there in Papua New Guinea and we can observe this mine through the years using satellite imagery. Now this is the mine in 1984. So, this is ok and we can see that this is a small area. Now, the important thing about this mine is that these people did not have a very good system of waste management.

Whatever effluents or whatever noxious chemicals were created by the mining operation, they were just dumped into the river. So, here we can see that we have this river and we have a river here as well. So, any of the dumping would be dumped into the river.

This is 1984, this is 1991. So, you can observe that this area has grown in size; we are also seeing a small growth in this side. But then the important thing is that, because of the polluting action of these minings that have been dumped into the river; we are also observing that the trees around the river are dying off.

This is the image from 1995. So, you can observe that on both sides of the river, now there is a

large portion of trees that have died down and the mine has increased even further . This is 1998. This is 2002. This is 2006. So, in all of these cases we are observing how these forests are getting destroyed.

From this: 1984, we get 2006, 1984 and 2006. So, what is happening here is that the trees are getting lost, the mining area has increased. So, here you can observe that the mine has increased in size 1984, 2006; then here as well there has been deforestation. So, this is an example of the impact of the mining operation on the local ecosystem.

Now, because oil spills and mining have such a huge impact on the ecosystems, we require strategies to protect the ecosystems. The first strategy is to avoid setting up oil rigs and mines in especially vulnerable spots. Now, in our country, it is mandated that there are certain go areas and there are certain no go areas. Now, certain no go areas especially those that are there around the national parks or wildlife sanctuaries or tiger reserves.

In those areas, if somebody wants to have a permission to set up an oil rig or to set up a mining operation; then this permission is frequently denied, because these areas are especially vulnerable. If there is anything that goes wrong, quite a large number of species will die.

In those areas where permission has been granted for oil rigs or for mining operations; we require better technologies, better technologies to prevent the spills, better technologies to reduce the amount of pollutants that are generated, better technologies to ensure that all the tailings are disposed of properly without polluting the environment. So, better technologies are required.

We need to develop models to anticipate the spread. So, if there is any oil spill in any area, which direction will it take. If you know the direction, then you can concentrate your cleanup operations or recovery operations in those areas. And so, we need to have mathematical models that can tell us where to concentrate our resources.

Similarly, if there is a mine that is being set up; we need to know where we can have situations of say landslides or if the tailings are being put into a dam, then where the dam can break, where can accidents occur, so they need to be known. So, we need to develop models to anticipate spread.

We need to maintain rapid response teams and technologies; because accidents can occur at any point of time, so it is always prudent to be better prepared. Utilize studies on long-term impacts and mitigation options. Now, we may not know everything; but there are a lot of studies in a lot of countries and most of these studies can be implemented in the local situations as well.

It is always a good idea to make use of these studies and try to improve the degraded habitats. Because if a habitat is already degraded and if you give it one more disturbance; then probably the ecosystem will collapse, the community will collapse. So, it is also important to improve the degraded habitats.

Now, in improving the degraded habitats, we have certain options that are available with us; the first option is recovery or neglect. So, in this case, we just say let nature take its own course; we may ameliorate the degraded habitat or we may even make it more degraded through such an operation.

When we say that we are following the root of the recovery or recovery through natural needs or of neglect; what we are saying is that, if there is a mind that has been set up and the mind has a

result, it has resulted in a huge area of earth that has been excavated, then we just leave it as such, because we say that ok nature will take its own course, the trees will come up and in a short while it will be, ok.

Now, it is possible that the site may become better by itself with time; because the trees will come and occupy this area. But it is also possible that if we do not do anything; then because of the heavy amount of soil erosion, this area will be even further degraded. Other option that we have is rehabilitation or reclamation, which is shifting the degraded habitat towards a greater value though not necessarily the original state

So, in the case of rehabilitation or reclamation what we are doing is that, we are not targeting to bring this degraded state back to the normal state. So, for instance in the case of our mine, the area that has been excavated; we will say that ok, we are not aiming to bring it back to the natural forest, but probably we will bring it to say an artificial plantation.

That is better than leaving the land excavated as it is, though it is not as good as bringing it back to its natural state. So, this is the second option, which is known as rehabilitation or reclamation, where we convert it into, where we will shift the degraded habitat towards the greater value though not necessarily the overall state.

If we aim to bring it to the original state, we call it restoration; restoration is actively trying to return the habitat to its original state. So, in the case of restoration, we are trying to bring it back to the same natural forest that was cut down for the mining operation.

Another option is enhancement, which is improving the value of the habitat. So, in this case we say that ok, we will not do much of the activities; but we will at least try to improve the value of this degraded habitat for the wild animals, such as construction of water holes for animals.

Another option that we have is replacement, which is creating a new habitat in place of the degraded habitat. So, for instance there was a forest that was mined; you have a mine pit. So, you do earthwork and water filling and convert it into a marshy wetland. Now, this marshy wetland is a very different habitat as compared to the original forest; but this is at least a habitat for certain organisms, it is better than leaving it as it is.

So, these are the improvement options that we have. If you have this degraded habitat, say, because of mining in a state of neglect, in which case it may remain degraded, it may further degrade or it may improve to some extent. The other option is reclamation.

Now, if in the case of reclamation; we try to change it or we try to bring it to the original habitat, but not to the full way . The third option is restoration, where we try to bring it back to the original habitat. And we may even do an enhancement, where we try to enhance its utility even further.

A replacement in which case we have converted this degraded habitat into our wetland habitat. So, we are not trying to bring it back to the normal state, we are not trying to bring it back to the forest state; but we are developing a different kind of habitat. So, these are the improvement options.

Now, in the case of mine restoration, there are different methods that we can use or different operations that we can do, such as flattening of waste dumps and landfills to prevent erosion. So, in this case what we are doing is that, the waste dumps that are left out. So, it is easier for water and

when to erode them.

So, we will try to level them down, so that the amount of erosion is reduced. We fill up the dug pits, so that the amount of leaking of chemicals into the water table is reduced; because these are now filled up with the earth or we cover with a layer of clay to prevent access to rain and oxygen.

So, in this case we are covering it with clay, so that rain water is not able to seep into those areas that have these toxic elements. And so, we are trying to again stop the amount of or reduce the amount of leaking into the groundwater. Or we can cover the area with a layer of topsoil and perform a plantation operation, so that you have trees in this area.

Or in the case of tailings dam; because they have a huge quantity of water and they also have a huge quantity of these toxic elements, we may try to evaporate the tailings dam to concentrate the waste materials in that area and once they have been concentrated to an extent, they may be removed from the area.

And these days it is also important to perform the environmental impact assessment, whenever we are trying to give permission for any such activity. Environmental impact assessment is a process of evaluating the likely environmental impacts of a proposed project or development.

This is done before the permission is granted. Before giving somebody a permission to set up an oil rig or to mine in a particular area; we try to study what could be the likely impact of this activity on the local environment; taking into account, the interrelated socioeconomic, cultural and human health impacts, both beneficial and advanced.

In the case of environmental impact assessment; we also take into account the related socioeconomic aspects, cultural aspects and health aspects. So, we try to ensure that all the stakeholders are positively benefited by any of these projects; if they are negatively impacted in a large way, then the permission should probably not be granted.

So, in this lecture, we had a look at two major large infrequent disturbances; the oil spills and mining. So, that is all for today.

Thank you for your attention, Jai Hind!

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Module 4
Threats to wildlife
Lecture 1
Push and pull factors

Namaste!

Today we begin a new module which is Threats to Wildlife. This module will have three lectures: push and pull factors or the localization of species threats through species and ecotoxicology and developmental hazards. So, let us begin with the first one, the push and pull factors that govern the localization of species.

We know that different organisms live in different portions of the earth. So, for instance we find polar bears in the arctic areas, we do not find polar bears in the state of Tamil Nadu. Or we find elephants in the state of Tamil Nadu, but you do not find elephants in Siberia.

Different organisms are found in different locations, the question is why are they found in different locations? What are the factors that govern the abundance and distribution of organisms in different places of the earth? Now, this question falls under the ambit of the field of biogeography.

Biogeography is the study of the geographical distribution of life on earth. It studies the geographical distribution of life, which life is located in which area of the earth and the reasons for the patterns. So, not just a description of which organisms are found there, but also what are the reasons.

Why do we not find polar bears in India? Why do we not find elephants in Siberia? So, the reasons are also studied in this field, the reasons for the patterns one observes on different continents, islands, and oceans. So, this is the field of biogeography. And for different organisms we define the range of the organism.

The range or distribution of a species is the geographical area within which the species can be found. So, for instance India is not a part of the range of polar bears and similarly Siberia is not a part of the range of elephants, but Uttarakhand is a part of the range of elephants, Tamil Nadu is a part of the range of elephants, West Bengal is a part of the range of elephants.

The range of elephants comprises all these locations, but it does not extend to a place like Siberia. So, this is known as the range of a species, the range or distribution of the species is the geographical area within which that species can be found. And when we see that different species are found in different locations, let us first have an overview of the major habitats that we have. Now, habitat as you will remember is the natural home of an organism, it is the natural

abode or home of a species.

Let us before we move forward have a look at what are the different kinds of homes that we have, especially in India. So, we begin with the Alpine Meadows. Now, the term Alpine refers to a very cold mountainous area. Meadow is a grassland. So, Alpine Meadow is a meadow or a grassland that is found in cold mountainous areas, in states such as Jammu and Kashmir or Himachal Pradesh or Uttarakhand. So, this is an image from the Dachigam National Park in Srinagar.

If you look at this Alpine Meadow here we find that there is this hill that is all covered with grasses, there are hardly any trees here because in such locations when you move to a location which is very high and which is very cold, typically the wind speeds also are very high and in the case of large wind pressures the trees might get uprooted. So, we typically find fewer trees in the Alpine Meadows.

This is another image from Uttarakhand. So, here again we find that this is an Alpine Meadow and it is all full of grasses. Now, the Alpine Meadows would support a large number of species that are dependent on the grasses and these include not just the large sized species such as the tahr, but also includes the smaller size species rats, mice, rabbits and so on.

So, we have Alpine Meadows. Next, we have a look at the Alpine forest, now here again Alpine is a cold mountainous area and this is the forest that is found in a cold mountainous area. Now, typically the Alpine forest will be found in locations where the height is less than that of the Alpine Meadows.

And the most common species that we will find here will be the coniferous trees. Now, these coniferous trees are adapted to a life, which is cold and mountainous. Typically we find that the leaves are very small and the leaves are arranged in such a way that whenever there is snowfall, the snow can fall down on the ground. It does not remain there on top of the trees otherwise; the weight of the snow would lead to the collapse of the tree.

These are the species that are adapted to a life in the alpine forest, we also find a number of animals in these areas. Another habitat that we have in our country is the moist deciduous forest. Now, a deciduous forest is a forest in which the trees shed their leaves in a certain season.

Now, this shedding of leaves can be, say, to prevent the loss of moisture so, in the dry season the leaves will be shed so that the loss of water because of transpiration is reduced. Another option is that we can have shedding of leaves in the winter season to protect the plant from extreme cold.

The forests that are dominated by such trees that shed their leaves in certain seasons are known as deciduous forests. And we have two kinds of deciduous forests in our country. We have the moist deciduous forest which typically has a large amount of moisture that is a larger amount of rainfall and the dry deciduous forest.

This is an image of the moist deciduous forest from Uttarakhand and here we find that this forest is dominated by the Sal trees and Sal associated species. This is an image from a dry deciduous forest in Madhya Pradesh. This dry deciduous forest here again you can find that the floor is completely covered with leaves, and there are very few leaves on these trees.

This is an image that was taken in the season when the trees are shedding their leaves. This forest is dominated by teak and teak associated species, and both these dry deciduous forests and the

moist deciduous forest are very good homes for tigers. Another habitat that we have in our country is the scrub forest.

Now, a scrub forest is found in those locations that have a very great scarcity of water. Typically the climate would be warm or hot and there would be less amount of rainfall. Now, because you have less rainfall, a large variety or a large sized tree cannot be supported in these areas, and so the typical organization would be an open forest.

The canopy is very less, most of the plants that we will have here will be of a short height so, we will find some grasses, we will find some shrubs and we will also find some trees, but typically the trees will also not be very high. Another habitat that we have are the sand dunes.

Now, sand dunes are found in those locations that are even more dry, so here you can see that the sky is completely blue. You do not have a single shade of clouds here. So, this is an image from Jodhpur and this is a sand dune. Now, these trees have been planted in this region. So, that the dunes get stabilized, but the typical vegetation is what you see in this location.

There is hardly any vegetation. We find some grasses, some shrubs, and a few trees, but that is pretty much all. But even in such areas, which have a very much dearth of water here, we also find a large biodiversity and we find some species that are endemic to these regions.

Now, an endemic species is a species that is formed only in one area nowhere else. So, we will find species such as this spiny tail lizard now, this is a species that is adapted to a life of intense sunshine and very less amount of water. So, we find this species in the desert national park for instance.

Another habitat we have in our country are estuaries. Now, estuaries are those areas where a river meets the sea; and typically we will find a gradient of salinity in an estuary from fresh water in the river to a brackish or saline water in the sea and there will be region where the salinity is in between so, we will find a gradient of salinity.

Whenever we find a gradient then typically we also find a large biodiversity, because these areas can support those species that live in freshwater they also support those species that live in salty water and they also support those species that live in salinity conditions that are between fresh water and salty water.

So, these are estuaries. Another habitat we have in our country is the Rann of Kutch. Now, a Rann region is a region which is typically very flat and in the rainy season it gets inundated with water, but then in the other seasons it is parched dry. So, typically you will find very flat regions where you will have certain grasses, there will be a dearth of water and you will find some endemic species such as the Indian wild ass.

This is an image from the Indian wild ass sanctuary. In areas where you do find water, typically the water will be brackish or saline, but these kinds of waters also support organisms such as the flamingos. Another specialized habitat we have in our country are the lagoons. Now, lagoons are those areas where the sea is able to enter into the land; and a lagoon such as the Chilika lake in the state of Odisha, provides a very unique habitat for organisms.

Why, because as in the case of an estuary even in the case of Chilika lake there are certain rivers that are draining into this lake. So, it is getting fresh water from one side, on the other side you have the sea, the Bay of Bengal and you have salty water that is getting in from the other side.

Here as well you will find a gradient of salinity, from very saline water near the sea to fresh water near the river mouth and everything else in between. At the same time Chilika is known for having a less depth of water so, typically the depth of water is less than 60 meters in most of the locations.

Now, that is important because a less depth of water ensures that the sunlight is able to reach from the top of the water column to the bottom. Which means that you have a source of energy everywhere you have light everywhere, which ensures that these sorts of ecosystems like the Chilika lake - they have a very high productivity and because of a good productivity because of all different sorts of variations in salinity we find a large biodiversity in the Chilika lake.

Another habitat we have in our country are the flood plains, such as the Brahmaputra flood plains that we are seeing here in the Kaziranga National Park. Now, flood plains are those areas that are near the river so, when it is the rainy season and the river floods these areas get completely inundated with water.

When that happens, all the plants in these areas or let us say most of the plants that are there in these areas get drowned under water and they die off. Then, in the post monsoon season as the water recedes, you get a ground that is more or less vacant and is also wet. So, in such grounds we get a very heavy growth of grasses.

These flood plains typically support large grasslands and also a large number of herbivorous species. Certain species such as the rhinoceros are endemic to this region. They are only found in these floodplains and they are not found anywhere else.

Another specialized habitat in our country is the shola forest, that you can find in the state of Tamil Nadu or Karnataka. Now, shola forests are a very unique ecosystem, because here we find a dynamic equilibrium between these grasses and these trees. The grasses do not invade into the tree areas and the trees do not invade into the grasses both eat each other in check.

Now, the benefit of such an ecosystem is that you know that an animal can use these grasslands for grazing and whenever it senses danger it can run into these forests to protect itself from the predators. So, these areas support a large diversity of organisms; and we also find a number of endemic organisms in these areas.

Yet another ecosystem or habitat in our country is the equatorial forest. Now, equatorial forest as the name suggests these are the forests that are near the equator. In our country we will find equatorial forests in the islands of Andaman and Nicobar. The equatorial forests are in those areas that are close to the equator and so they are getting a heavy amount of sunshine.

They also get very dense or heavy rainfall. Now, abundance of water and abundance of sunshine means that there is a very profuse growth of vegetation, and the ground gets completely covered so there is a complete canopy closure so, all the the canopies of different trees they touch each other.

Another characteristic of the equatorial forest is that the trees are very tall. So, you can see that this is an elephant for comparison and the size or the height of this tree is much greater than an elephant. Now, because there is a very fast growth of trees, you can also support lumbering or logging operations in these areas and here we are saying that an elephant is being used to pull this log of wood that has just been cut.

Equatorial forests also support a very large amount of biodiversity because there is an abundance of food production in these areas. Another habitat are the mangroves. Now, mangroves are forests that are found at the confluence of land and the sea.

The trees that grow in these forests are adapted to a life that is in between that of a land and the sea. So, typically we will find that they have these very dense roots and these roots are exposed and in certain locations these roots turn up and get exposed to the air they are known as pneumatophores; and they ensure that the roots get aerated.

Similarly, they also have a very unique adaptation that is known as vivipary. Now, in vivipary what happens is that, the fruits that are formed in these trees they germinate when they are out there in the tree itself. So, the plant forms and once the plant has formed completely and it is a low tide plane, the plant will just drop down and it will get established in the sand that is below.

So, we have very specialized kinds of adaptations that we find in the mangrove trees, and they also support a very large biodiversity because these roots can be used as a shelter. And a number of fishes lay their eggs in the protection of these roots. So, mangroves support a very huge amount of biodiversity.

Yet another habitat that we have in our country is Oceans and Seas, which also have certain specialized organisms. So, our country is blessed with a wide variety of habitats and in each habitat you will find an organism that is found only there and it is not found anywhere else. Now, the question is we have different habitats, but then what governs which organism will be found in which area. So, which brings us to the topic of the distribution of species such as a snow leopard?

We are taking this example of snow leopard, if you plot the locations where snow leopard is found you will get a map such as this. So, the yellow colored region is where the snow leopard is found, and the pink color region is the one where it probably may be found but we do not have very good evidence.

Now, you can observe from this map that snow leopard is found in these mountainous areas, it is not found in our northern plains, it is not found in the Deccan peninsula, it is not found in the desert, it is only found in these areas. Now, the question is why do you find snow leopards only in these areas.

Now of course, the snow leopard has certain adaptations such as when it lives in the snow its color is very much similar to that of the snow so, it is able to camouflage very easily. At the same time it also has a very good amount of fat and the fur coat that it has is able to protect it from the snow.

But then, these are the adaptations that make it possible to live in the snow, the question is why does it live in the snow at all in the first place. Similarly, if we plot the location of coral reefs, now coral reefs are found only in these areas. Now, typically the areas where the coral reefs are found are those oceans, where the ocean temperature is neither very hot nor very cold and you also have clear water; it is not found in muddy waters.

Now the question is why is it found there. Now, one thing that we can note here is that most of the organisms are found in those locations that have a particular sort of climate. So, a coral reef

will be found in those areas that are not very hot nor very cold so, essentially you can mark the oceans where you have a temperature that is a moderate temperature.

In that you can also mark those areas that have muddy waters and those areas that have clear waters, and then you can say yes, this is the location where coral reefs should be found, which brings us to the topic of climate. So, it has been found out that climate plays the largest chunk of role in deciding or determining where an organism will be found.

And a good way of understanding that climate has the largest impact is by looking at altitudinal zonation. So, what this curve is showing us, is that if you move from the equator towards the poles you find that earlier you will have the tropical forest or the equatorial forest, after that you will find subtropical forest, after that you will find warm temperate forests followed by cool temperate subarctic and arctic regions.

Now, this is occurring when you are moving from the equator towards the poles. However, if you take a location such as this location which is at 10 degrees latitude and if you go and if you start going up a mountain then, what do you find? You find that up to around 1,000 meters, you will find the typical tropical forest in these areas.

But then, from an altitude of 1,000 to 2500 meters we will start observing subtropical forest. Now, remember that this is a location that is very close to the equator, but still you are observing a subtropical forest area. Then, if you move even higher in altitude, you will start finding the warm temperate forest or the warm temperate vegetation.

Now, this brings us to the point that there is something that is common between say this region between 30 and 35 degrees latitude and this region which is at 10 degrees latitude, but is at a greater height. So, what is that common thing, now it turns out that the common thing is the climate.

As we move up a mountain the temperature goes on reducing and so, after a level we will start observing the subtropical forest and the warm temperate forest and so on. So, the trees that are found here, near the equator but, at a greater altitude they will be very similar to the trees that are found here near the sea level, but at a greater latitude.

This is an example that tells us that because of the similarity in climatic conditions we find similar sorts of vegetation, but here again the question is why does this vegetation occur in these areas. So, we are observing that in areas with similar climates we are finding similar vegetation, but the question is why is this vegetation found here.

This brings us to the enfold factors. The question is why are things where they are? And we can say that there are certain factors that pull the species towards them and there are certain other factors that push species away from them. So, these are the pull and push factors.

Pull factors are conditions that attract organisms to any area, such as good amount of food availability and an amiable climate that suits the species. So, if there is a region with an abundant amount of food and with a good climate then, species will come to that area.

On the other hand, there are certain push factors that drive the organisms away from an area, such as the scarcity of food or an inhospitable climate. So, if there is a scarcity of food, if there is a climate that does not suit the organism, probably the organism will not be found there.

For instance we can say that the polar bear is finding a pull factor in the arctic's because it is get-

ting food in sufficient quantity it is not having any predictors of itself. Whereas, our location such as Madhya Pradesh offers a push factor to the polar bears because their temperatures here are too high and these temperatures are not amiable to the polar bear.

So, we have different push and pull factors and whenever we observe that a certain species is found in certain areas, we can start thinking about the push and pull factors. If we consider this image from the Shivalik hills here we find that these slopes are completely devoid of vegetation. Whereas these areas are thickly vegetated now, the question is why are these areas bare and why are these areas thickly vegetated? Now, if you start thinking on the lines of push and pull factors, you will start to think that there is something in these areas that is not permitting this vegetation to thrive.

There are certain push factors. What are those push factors? You can observe that these areas are very steep and in these steep areas whenever any soil gets formed with the next rains it falls down. And so these areas are typically devoid of soil now, plants require soil to grow and so, if you do not have a soil here then probably you will not find plants here.

The absence of soil is probably acting as a push factor for the plants in these areas. Another push factor could be the lack of moisture now; these areas are the south facing slopes. Now, Uttarakhand is in the northern hemisphere and so the south-facing slopes will have a greater amount of sunshine as compared to the northern freezing slopes.

And because of an abundance of sunshine the moisture gets evaporated. So, these areas not only have an absence of soil they also have less amount of moisture. So, these could be two push factors that are not permitting the plants to thrive in this area. On the other hand, if you consider this region then the slope is much lesser as compared to this region and because of that the soil is able to remain in this location.

And when you have soil and also you have more moisture because this is not the south facing aspect of this hill. So, you have more soil, you have sufficient amount of moisture and these are acting as pull factors for these plants to thrive in this region.

So, there are push and pull factors that can help us understand why certain organisms are found in certain areas and not in other areas. Now, in this context we can also look at Liebig's law of the minimum. Liebig's law of the minimum states that, the rate of any biological process is limited by that factor in the least amount related to requirement, so that there is a simple limiting factor.

The rate of any biological process including say the growth of plants is limited by that factor that is there in the least amount relative to requirement, so that there is a single limiting factor. Now, what does that mean? Let us consider that in a location where the plants are going plants require several nutrients.

And three most common most important nutrients are nitrogen, phosphorus, and potassium that we call as N P and K. Now, suppose the plants require 1,000 units of nitrogen, but only say 800 units are available, which is 80 percent. Now, in this location for phosphorus a plant requires 200 units of phosphorus, but only 100 units are available; which is only 50 percent of the requirement can be met at this particular site.

For potassium probably the plants need only 100 units, but only 99 units are available. Which

means that it is present in 90 times it is able to meet 99 percent of the requirements of plants. Now, Liebig's law of the minimum states that the rate of growth of plants will be limited by a single factor, they will not have the growth of plants that is limited by all these three factors. There will probably be only a single factor and that single factor is the one that is available in least quantity related to the requirement.

In this case the phosphorus is available in the least quantity related to requirement, because it is able to meet only 50% of the requirements of the plants, others are able to meet 80 percent and 99 percent. So, Liebig's law of the minimum will say that the rate of plant growth will be dependent on the amount of phosphorus in this area.

The rate of any biological process is limited by that factor and least amount related to requirement, so that there is a single limiting factor. Now, why is Liebig's law of the minimum important? Because it is giving us an indication of what could be a push factor in this region.

We can note that the phosphorus - because it is available in a very less quantity related to the requirement - so this lack of phosphorus in this case is acting as a push factor. Another similar concept is the Shelford's law of tolerance, which states that the geographical distribution of a species will be controlled by that environmental factor for which the organism has the narrowest range of tolerance.

There is a certain range of tolerance, for different environmental factors and these ranges of tolerance govern where this species will be found or not. Now, of late what we have observed is that the environmental conditions are changing and so even for those environmental factors for which the organism earlier used to have a narrow range of tolerance it is now possible for organisms to extend their reach; and a good example is of global warming.

Now, it is known that a number of insects are regulated in their distribution because of the temperature. So, a number of species of mosquitoes for instance cannot tolerate a very low temperature, and so because of altitudinal variation of temperatures we will find that in a mountainous area, the mosquitoes or the flies will be found in the lower areas and as we go up we will not find any of these mosquitoes or flies.

Because these species are adapted to a life at higher temperatures, but because of global warming what we are observing is that the temperatures are rising and so even in these higher up locations now, we are having a higher temperature, which is now within the range of tolerance of these flies or mosquitoes. And because of that we are observing that now the flies and mosquitoes are able to invade even higher reaches of the mountains.

Even if the range of tolerance remains the same, if there is an environmental variation that brings more areas into the range of tolerance then the organisms will extend their range. This is the field observation as the mean temperatures are rising the median altitude where mosquitoes are found or where malaria is found is also increasing.

We are seeing this thing practically. Now, another factor that acts as a push factor is Allelopathy now, Allelopathy is the phenomenon in which certain organisms secrete certain chemicals that inhibit the growth of other organisms or that kill away other organisms, and a very good example is antibiotics.

This is a photograph from the Nobel lecture of Alexandra Fleming and here we are seeing that

there is this petri dish on which there is this colony of penicillium which is a moon. Now, this penicillium colony is secreting something and now we know that that something is penicillin the antibiotic, and because of this antibiotic and here we are seeing bacterial colonies which belong to staphylococci.

Here we have staphylococci colonies and in this zone where you have the penicillin, we are seeing that these staphylococci are undergoing lysis. So, the penicillium colony is secreting something that is killing off or inhibiting the growth of these bacteria.

A phenomenon such as this is known as Allelopathy and we find Allelopathy not just in these microorganisms but also in the case of plants. So, if you consider a dry deciduous forest floor and especially one that is dominated by peaks you will find very less vegetation in the ground cover.

Now, why is that so, because the leaves of teak when they fall down, they carry with them a chemical that inhibits the growth of a number of species of plants. So, we find Allelopathy because of these leaves in a dry deciduous forest as well, and in a number of cases we can demonstrate this impact experimentally.

Similar to the impact of teak it is known that in areas that have grasses it is difficult to raise apple trees. So, how do you demonstrate that the grass is doing something through Allelopathy to reduce or to inhibit the growth of the apple trees? Now, remember that in the case of Allelopathy something is being secreted and if there is something that is being secreted if you take that chemical out then, it should still be able to inhibit the growth of the apple saplings.

This is how the experiment is done. So, you take soil in which you have grass, you add water and you take off the runoff. So, here we are adding water and the water is percolating through the soil and the runoff and the water that has been populated down it is collected, and here you have another piece of soil in which you are growing apple tree seedlings and here also you do the same thing.

And you find that, because you are adding water from outside, the grass is able to grow and the apple tree seedlings are also able to grow. There is no difference or there is no mortality or more innovation. Next, what you do is you add water to this grass and you remove this water that has percolated through this grass and soil or has flown over this grass and you add this water to the apple saplings.

Now, you will start to observe that these apple saplings or the seedlings will be showing a very reduced growth as compared to this control. So, in this control we were adding water from outside, in this experiment we are adding that water that has passed through grass and the grass roots; and we are observing that it is now inhibiting the growth of the apple seedlings.

Probably there is something that is coming out of this grass or the soil that is inhibiting the growth of the apple seedlings. Now, how do we prove that it is not something that is coming from the soil? Well we repeat the same experiment, but without the grass.

Now we add water to the soil. We take all the water that has run off or that has populated through this soil and we add that water to the apple seedlings, and here we find that there is no inhibition of growth. So, such an experiment would help us prove that there is something that is being secreted out by the grass, not by the soil and this something is hampering the growth of the

apple seedlings.

This is the classic Allelopathy. Allelopathy can very easily be demonstrated in experimental settings in certain cases we grow two organisms together and we observe, if this organism is able to inhibit the growth of this organism, but at a distance or we can do experiments such as these to demonstrate if something is being secreted out which is inhibiting the growth of the other species.

Allelopathy is a very important push factor for a number of species. Another push factor is predation. Now, predation is the phenomenon in which one species kills or hunts or eats other species for food. So, for instance if there is an area which has a very big population of say wolves.

In those areas we will not find a very big population of deer. So, the deer will try to avoid those areas where you have the wolf population, whereas the wolves will be attracted to those areas that have the deer. So, predation works in these two ways.

A very classic example of predation is how sea urchin regulates the distribution of algae. So, this is a field observation so, here you have the abundance of sea urchin. Now, here sea urchin is the predator that eats up the algae and here we find that in so, this is the abundance of sea urchin and this is the abundance of algae.

And here we find that wherever you have a heavy growth or heavy abundance of sea urchin you do not find the algae, but in those locations where you do not have the sea urchins you have a very good amount of algae. Now, how do we prove that this distribution is because of sea urchin and not because of any other organism.

We show this by experiments. So, the scientists took an area where they were not finding the algae and they experimentally removed the sea urchins in those locations. Experimentally all the sea urchins were picked and moved to other locations. What happens in the absence of the sea urchins, is that the algae start to grow and occupy this area and within a year - so, this experiment ran from July 1959 to July 1960 - within a year the whole area got covered with algae.

If you just remove the sea urchins you find that the algae have come back to this area, which tells us that the sea urchins were doing something to the algae because of which they were not able to thrive in this location. But then, not only does predator govern the abundance of the prey in certain cases the prey also governs the distribution and abundance of the predator.

A good example is those locations where you find deer or sambars and you find tigers in those locations. So, if you have the prey you will find the predators nearby, but in certain situations this goes to the other extreme as well. For example, in the case of *Drosophila pachea* now *Drosophila pachea* is a predator species which preys upon a species of cactus.

Now, this species of cactus not only provides food for this *Drosophila*, but also it secretes or it manufactures a particular sterol that is required for the development of *Drosophila*. So, if you do not provide this sterol, if you try to grow *Drosophila* on some other species the *Drosophila* colony will not be able to establish.

So, in this case this *Drosophila pachea* or this predator will only be found in those locations on earth where you have this particular cactus. So in this case, the prey is governing the distribution and abundance of the predator; in this case the prey is acting as a full factor for the predator.

Another factor that governs the distribution is competition, especially interspecific competition. Now, interspecific competition is a phenomenon in which there are two species that are competing against each other. And during this competition it could be say for food or it could be for space, during this competition one of the species is able to have so much amount of aggression that it drives away the the species from that area.

And a good example is these birds the red wings and the tri colored black birds. Now, this is a field observation. In 1959 on 15th of March it was found that this whole area was covered with redwing territories, but later on on 20th of March it was found that the central region had the blackbird territories and the red wings were displaced out.

So, they could only remain in the periphery, but the central region is now a space where these red wings are no longer found. So, this is an example of interspecific competition that governs the distribution and here the black birds are acting as push factors for the red wings.

They are pushing them away from their original territories. There is nothing else in this area that is unsuitable for the red wings, the red wings could have easily formed their colonies and as they had done previously, but then because these black birds are acting in a push factor so they are pushing them out of this region.

This is another factor that governs the distribution and abundance of species. Another factor is the behavioral factors, such as habitat selection "Habitat selection refers to a hierarchical process of behavioral responses that may result in the disproportionate use of habitats to influence survival and fitness of individuals".

In the case of habitat selection what we are saying is that there are two habitats that are equally suited for an organism, but it so happens that the organism does not prefer one it only prefers the other one; and because of this behavioral response it is possible that the organism will be found only in one habit and will not be found in the other habitat.

And a good example is the chipping sparrow. Now, this experiment was done to demonstrate that habitat selection has both innate and learnt responses; innate means a response that is present from birth and learnt is something that the organism learns after it has been born.

In the case of natural chipping sparrows the wild caught adults if you take this if you take the birds if you catch the birds that have grown in the wild conditions, and if you put them into a situation where they can spend time on pine trees or they can spend time on the oak trees, you will observe that as much as 71 percent of the time is spent of the pine trees so, the majority of time is spent on the pine tree and only 29 of time is spent on the oak trees. Now, in this case what is happening is that the oak can also serve as a habitat for these birds.

It also provides them with shelter, it also provides them with a place where they can boost or nest, but they have a behavioral preference for pine. So, this is an example of a habitat selection. Now, it has an innate component which is present from birth because if you have laboratory reared, birds which have not been exposed to any outside foliage then also we observe a very similar pattern, they spend as much as 67 percent of time on pine when they are released and only 33 percent of time in the oak.

Which means that, this habitat selection or this preference for pine is present from birth, but then if you have laboratory reared chipping sparrow chicks and you raise them in oak foliage so,

when you are raising these chicks you put the oak leaves together with these chicks.

What happens is if this slowly and slowly they develop a preference for oak as well. And when you release them out in the forest you will find that now they are spending 54 percent of their time on oak and 46 percent of their time on pine. Which means that, earlier we were seeing a dramatic preference for pine, but now we are not seeing a preference for pine?

Now the birds have become ambivalent; they spend time in oak roughly as much or a bit more than the time that they spend on pine. So, habitat selection has a learned component as well and habitat selection can be changed. Other factors that govern the distribution of species are things like dispersal. Dispersal is the movement of individuals away from their place of birth or hatching or seed production into a new habitat or area to survive and reproduce.

What we are seeing here is that, if you consider a tree and this tree is giving now a number of fruits and seeds, if all the seeds grow into plants in this same area the area will very soon become overcrowded and there will be a very heavy amount of competition.

So, typically what happens is that there are mechanisms through which these seeds are able to move to other locations. Such as in certain plants you will find that the trees are surrounded by a cotton like ball and then together with the wind they are able to move to other areas, or in certain cases we have movement because of water.

In certain cases we have fruits that are edible so, birds and animals eat these fruits and when they go out to other locations and when they defecate the seeds are also able to reach these other locations. So, this is a phenomenon that is known as dispersal. The movement of individuals away from their place of birth or a hatching or seed production into a new habitat or area to survive and reproduce.

Now, dispersal is different from migration, because in the case of dispersion the organisms are moving not along fixed booths and not in a regular or seasonal manner, but they are moving in search for a better habitat. Now, dispersal is of three different kinds, you can have diffusion which is a gradual movement over several generations across hospitable terrain.

In diffusion you have the organisms that are moving over several generations and the terrain is a good terrain and so slowly and steadily they are moving, such as the movement of lions across the Gir landscape that is diffusion. In certain cases we have the jump dispersal which is a quick movement over large distances often along unsuitable terrain.

There is a quick movement over large distances often across unsuitable terrain; a good example is the dispersal of zebra mussels through ballast water or say the movement of rats on ships. Now, if there are two islands and the first island has rats, the second island does not have rats and between these islands the area is covered with water.

Now, water is an inhospitable terrain for the rats because they cannot swim and they will die if they try to swim over these long distances. But, if a ship is moving from island one to island two, and if the rats are able to get into this ship they will be able to cross this inhospitable terrain very quickly probably in a single generation. So, this is an example of a jump dispersal quick movement over large distances and often across unsuitable terrain.

Another example is the invasion of zebra mussels through ballast water. So, when ships move from one place to another place to maintain the stability there is a structure called ballast and

whenever there is loading of goods then, water is pushed out of the ballast; and whenever there is unloading of goods water is pumped into the ballast.

And when that happens, whenever there is pumping of water into the ballast, then the organisms that are out there in the lake or in the sea where the ship is located they can also enter into the ballast. And when the ship moves to another location then these organisms are also able to hitch-hike, because they are there in the ballast water.

So, the surrounding waters may have become salty and in the salty water these zebra mussels would have died, but because they are inside the ship inside the ballast where there is fresh water, they are able to survive. Now, when they reach another location and when again there is pumping in and out of water then, these zebra mussels can come out and this is an example of a jump dispersal.

Because, there was an inhospitable terrain in terms of high salinated water, which the zebra mussel was able to cross very quickly in one generation or in the span of a few generations. Another mode of dispersal is the secular dispersal, which happens so slowly that the organisms have finally diverged from the original populations, such as the dispersal of humans out of Africa.

So, we have these three different modes of dispersal, and whether a species is found in a location or not also depends on whether it has been able to disperse to that location or not. So, in the example of our two islands, island two did not have a rat population, but if you have a dispersal from island one to island two we will start observing rats in island two as well.

Because island two was able to meet all the other requirements of rats, it was having space it was having food but, till the point that the rats are able to reach that island we will not find rats in that island. Other factors are anthropogenic factors or manmade factors, this clearing of forest or pollution.

In this image we can see that this area is clear-felled now, if humans had not acted here this area would have had the same trees that are found in this area. And human factors are playing a major role in the case of the abundance or distribution of different organisms.

Now, we can understand the reasons why an organism is found in a certain region or not through transplantation experiments. Now, in the case of transplantation experiments what is done is that and the is that a group of organisms is transplanted from a site where they are found, that is this green site to another to other sites where they are not found, such as this yellow site and the red side and there is also control experiment.

Now, if you take organisms from this green zone into the yellow zone and the organisms are able to survive. It would tell us that there is nothing wrong with this area everything is fine it is just that the organisms have not reached to this area, probably because they have not been able to disperse to that area so, it will take a bit more of time, which is our example of rats moving between the two islands.

But, if we do any transplantation experiment from this green to the red zone and the organisms die, then we will see that there is something in this red zone that is not allowing these organisms to thrive. A good example is when algae are shifted to areas that have sea urchins.

So, transplantation experiments are used to determine whether the range is limited or the distribution is limited because the area is inaccessible due to a physical barrier or it is a factor of dis-

persal that it will take a bit more time, or whether there is a habitat preference.

Or whether the distribution is limited by other species such as because of predation parasitism competition and so on, or whether its distribution is limited by physical and chemical factors. So, transplantation experiments help us decide what is the reason for a particular abundance and distribution or localization of the species.

So, to sum up we can analyze why a particular distribution is there by looking by performing different experiments and by having different observations. If an area is inaccessible such as our second island in the case of rats moving from island one to island two, if there is if everything else is fine but the area is inaccessible we will say that the localization is because of dispersal or absence of dispersal.

But, if the area is inaccessible then if we observe that there is a preference for a particular habit and if there is a habitat selection, then we will say that the localization is because of behavioral aspects. If behavioral aspects are also not there the species has equal preference then, it is possible that the distribution is limited because of predation parasitism competition or disease which are biotic factors.

So, we can perform transplantation experiments and see if it is because of say predation or because of parasitism. But, if that too is not there, if this is there then we will say that other species or biotic components are regulating the distribution, if even that is not there then we will say that it is because of certain physical and chemical factors.

And if we change these physical and chemical factors, say by use of greenhouses or by adding water or by providing fertilizers; we will be able to show whether it is because of a particular physical or chemical factor or because of something else. By doing such experiments by doing such analysis, we can discern what are the push and pull factors that are governing the localization of any particular species.

That is all for today. Thank you for your attention. Jai Hind!

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Module 4
Threats to wildlife
Lecture 2
Threats to species

Namaste!

In today's lecture, we will have a look at the Threats to Species. The threat factors can be discerned from ecology and in the last lecture, we had seen that there are a number of push and pull factors that decide whether an organism will be found in a particular place or not.

Pull factors as you will remember are those factors that attract organisms to them. So, they could include things like a good climate, a good soil, ample amount of food and so on.

Whereas push factors are those factors that push the organisms away from them and they include things like a climate that is very hot or very cold or very dry, so areas that do not have good amounts of food available for them or areas that have predators or diseases.

These are the areas where these factors would be pushing the species away from these areas. So, any organism that is found in these areas, there is a very good chance that either this organism will be killed or this organism will shift to some other place.

There are certain push factors and certain pull factors. Now, when we talk about the threat factors, then if an organism is a threat, what does it mean? It means that the organism is facing push factors everywhere and it does not have a pull factor anymore, which means that from all the areas, this organism is being pushed out and there is no place where this organism is finding a habitat that is suitable for itself.

The threat factors discerned from ecology are that you have push factors everywhere and pull factors nowhere and that would be a major threat to any wildlife species. And if you look at these push factors, we can divide them into certain categories. So, the first one has no suitable habitat. You have an area which does not provide a suitable habitat for the species. It is either too hot or too cold or there are no trees. So, there is no shelter that is available for the organism, there is no food, there are no nutrients in this area or an area that is completely burnt out. So, probably there was a forest fire and this forest fire burnt away all the habitats of a particular species.

In that case, this organism will not be having any other suitable habitat in which to live - areas are rich in noxious factors or are too polluted. For instance, there is a species that is found in a particular lake and this lake is now being used as a dump site for industrial accruals.

When that happens, the organisms will lose out their habitat or areas that are not suited behaviorally because of habitat selection. Probably an organism could have thrived in an area, but then,

this place is all full of such trees that its habitat selection does not permit to use or to prefer as a habitat.

These are push factors that are related to the habitat. Then, there are certain other push factors that are related to competition. Probably, the habitat of the organism is now full of invasive species.

Invasive species are those species that when they come into a habitat, they grow so profusely and they out-compete the native species to such an extent that in a very short period of time, you will only find these invasive species that are predominating these areas.

If an area has invasive species, then probably the habitat will go back or areas that have too many predators or diseases. So, the organism could have lived there, but now there are so many predators in that area that any organism that remains in this area might get killed off or there are a number of diseases in those areas.

There could be competition because of invasive species, because of predators and so on. So, these are other push factors or you could have the push factors of being killed out, specially to by human beings; say due to heavy poaching.

So, for organisms such as tigers, this is a major threat. Then, we also have other push factors in the form of small population dynamics. Now, small population dynamics act when the population has already become very small and these include things such as Allee effect or stochastic difference.

Allee effect is an effect that occurs when the population size has gone down. Now, in the case of a number of species, the size of the population plays a very important role in how efficient this population and the individuals of the population are.

For instance, if we consider a pack of wolves. If there is a single wolf, it might not be able to kill the prey. So, it requires a certain small number of wolves that should be there so that the prey is killed effectively and all the individuals in the pack are able to get their food.

Now, if the pack size reduces to such an extent, that you only have a few wolves. So, these wolves will not be able to hunt in an efficient manner and in that case this would start acting as a push factor for this small pack of wolves. So, this is known as the Allee effect or you could have stochastic deaths.

Stochastic deaths means that you have a random death that is occurring in this area and it is just possible that you already have a very small population, say around 4 individuals and these 4 individuals die off or 3 out of these 4 individuals die off.

Now, this would not have had a big impact if the population size was large. In a pack of say 40 wolves, if 3 individuals died, it could not have mattered much. But in a pack of 4 wolves, if 3 individuals die off, the lone individual will not be able to breed any further and this pack will be as good as gone.

These are the impacts that occur when the population sizes vary and these are known as small population dynamics. So, these are all different threat factors that we can discern from the ecology of different species.

There could be the push factor of an unsuitable habitat everywhere or there could be a biological factor that these individuals are getting completed out because of a invasive species, because of

predators or humans could be involved in killing out the individuals of the population or there could be the small population dynamics because of which there is a big threat to the small populations.

When we talk about these push factors, these push factors can be divided into two categories. There are factors that push a population towards smaller numbers. So, here the population is currently large in size and these are the factors that are pushing the population towards a smaller number.

And these are known as Declining population paradigm. So, the declining population paradigm is the study of those factors that push a large size population towards the smaller numbers and this occurs through population dynamics.

On the other hand, we also have the Small population paradigm which occurs due to factors that push a small population towards extinction. So, in the case of the declining population paradigm, you have a large population and the declining population paradigm is converting a large population to a smaller population.

Whereas, in the case of a small population paradigm, we are talking about a small population that is now being eliminated. So, the small population paradigm comprises factors that push a small population towards extinction.

We can categorize our push factors into the declining population paradigm because of smallness such as things like no suitable habitat. So, if the habitat is becoming unsuitable it is, say, because of climate change. If climate change is occurring in an area, then it is possible that the habitats become too hot or they become too dry or too wet and when such a scenario occurs, then it is possible that the large size populations will now be pushed towards smallness.

Because they are now not getting sufficient food, they are not getting sufficient suitable habitats in which to thrive or we can have this competition. So, competition also pushes a large population towards small size populations.

Or poaching. Now, poaching or heavy poaching, generally reduces a large population into a smaller one. And in the case of the small factor paradigm, we can consider these small population dynamics such as the Allee effect and the stochastic deaths.

Now, when we talk about any population, a population is composed of individuals of the same species that are living in the same area and can potentially interbreed amongst each other. So, basically, we are talking about the small cohesive group of individuals.

Now, if you consider any population, there are two factors that are occurring at all times. Now, these factors are the deterministic factors and they are the stochastic factors. Now, deterministic factors act at large population sizes and stochastic factors are more important when the population sizes are smaller.

What are these factors? The deterministic factors are the factors that act at large population sizes. So, these include things like birth rate, death rate, population structure and so on. So, basically if you have a population, a large size population and the birth rate has gone down or say the death rate has gone up.

Now, why could such a thing happen? Probably, there is some pathogen that is affecting the breeding females because of which a spontaneous abortion occurs. So, that would reduce the

birth rate in this population or probably, there is an infection that is killing off the individuals because of which the death rate has increased.

Now, these sorts of factors, the changes in birth rate and the changes in death rate, are important even when your population is large in size and so, these are deterministic factors. So, things like birth rate, death rate, population structure; suppose, your population is now composed of individuals that are very old.

It is just a matter of time that the population will collapse because these very old individuals will not be able to breed. So, at all points of time, you need to have a population structure that comprises certain young individuals, a number of mature individuals and some old individuals.

And the population structure should also be such that you have roughly equal numbers of males and females. Now, if you do not have a suitable population structure, then even if you have a small a large size population, it is possible that the population might be pushed towards smallness and so, this is a deterministic factor.

On the other hand, the stochastic factors which are more important when the population sizes are small comprise things like demographic stochasticity. Now, demography's demographic stochasticity includes occurrence of probabilistic events such as reproduction, litter size, sex determination, and death.

What do we mean by demographic stochasticity? Suppose, you have a large population; suppose, you have 1000 individuals and, in this population, you have 500 new young ones that have been born in this particular year.

Generally, the sex ratio is close to 1 is to 1. So, out of these 500 500 young ones, you have 250 males and 250 females. Now, what happens if by chance it happens that more males are born?

In place of having 250 males, suppose you have 300 males and you only have 200 females, will that make a very big difference to this population? Probably not. What about if you had say 400 males and 100 females?

Well, it might have a certain influence; but again, this is just a chance factor. It is possible that in the next letter, you will have more females. So, it does not matter much when we consider a large population.

But now consider a small population. So, you have a small population that is composed of only 3 individuals and these and you have 1 breeding pair and these 3 individuals which have given rise to a litter and it so turns out that the litter comprises say 2 males.

In the parent generation, you had 2 males and 1 female and in the next generation, you again came up with 2 males. Now, this is a random phenomenon. It can occur in any population. But in the case of larger size populations, some deviation would have been quite acceptable.

But in this small population, it so happens that the females have gone down in numbers so fast that now you do not have sufficient females for this population to continue. So, demographic stochasticity plays a very important role in the case of small populations and so, this is a stochastic fact.

Another stochastic factor is environmental variation and fluctuations. Now, the environment and the weather of any place is variable and it might so happen that in a particular year, it turns out to be a droughts like situation. Now, in a drought like situation, if you have a large population, a

number of individuals would die off.

Probably you started with say 1000 individuals and out of those 1000 individuals, 500 individuals perished in the drought. So, this could happen. But the 500 individuals that remain will be quite sufficient to take this population back to its original state.

Probably in the next year, when it rains better, then the population will be able to jump back to its original state. But now, consider a very small size population, suppose you only started with a population that comprised say 5 individuals. Now, in these 5 individuals. suppose 3 or 4 individuals perished in the drought.

The 1 or 2 that remain might not be sufficient to take this population back to the normal state, which is why the environmental variation and fluctuations are also stochastic factors that are very important when the population sizes are smaller. Then, we have catastrophic factors such as forest fires and diseases.

These are also much more important when we talk about smaller populations because we are talking about the perishing of a large number of individuals from the smaller populations. So, this would push these small populations to such small states that probably the population will not be able to come back to its original state.

Other stochastic factors include genetic processes such as loss of heterogeneity and inbreeding depression. Now, what we mean here is that in the case of a small population, it is possible that all the individuals that are there in the population are related to each other and in that case, when a breeding happens between these individuals.

It is possible that you have breeding between brothers and sisters or you have breeding between parents and children. When that happens, the recessive alleles that are there in the individuals, they get a chance to express themselves and in such scenarios, we will find a number of recessive disorders that come up into these populations.

You will start seeing diseases, which are recessive diseases, which would not have expressed themselves had this population size being larger and had these breeding's occurred between individuals that were not related to each other.

But now because the population size is small, there is a much greater chance that inbreeding depression occurs and that would be a genetic process that is leading to extinction because of the stochasticity.

Or we have things like deterministic processes such as density dependent mortality on exceeding the carrying capacity of the habitat. Now these processes, what we are talking about here is the density dependent mortality.

Now, in a number of species in a number of species it has been observed that as the population density increases, the rate of mortality increases. Because you have a large number of individuals that are there in a very small area and there are very continuous contacts between individuals.

There is much greater aggression, much greater competition and diseases can also spread in a much quicker manner. Now, if we talk about a small population which comprises a small area.

Then, even though your population size is small, the population density is very large. Because of which, we will start seeing density dependent mortality. And this is again a stochastic factor that becomes much more important when the population sizes are smaller.

When the population sizes are larger, then the density dependent mortality is a mechanism by which the population size is getting controlled. So, when the population increases very much, then a number of individuals die off and the population comes back to the level of carrying capacity of the habitat.

That is ok when the population sizes are large. But when the population sizes are small, then it becomes a very important factor that can push the population towards extremes. Then, we also have the factor of migration among the populations.

Now, we have seen in an earlier lecture what migration is. So, migration is the movement of individuals from one place to another. Typically, it is a seasonal movement and typically, it occurs along fixed groups.

Now, if it so happens that in a population you have say 4 individuals and out of these 4 individuals, there is 1 female and this female migrates out. So, the 3 males that remain in this area will not find a partner to breed and in that case, this small population will turn towards extinction.

It is a very similar manner, if you have 3 females and 1 male and the male goes off. So, such factors become very important, when the population sizes are small. If the population sizes were large, say in a group of 1000 individuals, say 10 or 20 or 100 individuals move out during a migration period, it's fine. It does not make much of a difference.

But in the case of smaller populations, if it so happens that members of a particular sex move out, then it is possible that the remaining members may not find partners and the population will be pushed towards extinction.

Now, the factors that drive a species towards extinction can very easily be remembered using this acronym HIPPO. Now, the first H refers to habitat loss. The habitat is getting lost and if a particular species does not have suitable habitat.

It will not have a place to live and this factor will lead or push the species towards extinction. I refers to invasive species; so, invasive species if they come to the habitat of your species of interest and they can lead to the degradation or loss of the habitat.

Next is pollution; so, pollution reduces the quality of the habitat because of which it is unable to support a large number of individuals. The next P is human overpopulation. Now, these days' humans are the most important factor when we consider the extinction of species.

More the number of humans in an area, more is the impact of these humans. Because more number of humans, more amount of affluence it would mean that more amount of pollutants are being released into the environment, more and more amount of resources are being taken from the environment.

In a number of cases, we have seen that in a forest if there is a small pond and this pond would have met the requirements of the wild animals. Now, if a village comes up in the vicinity, then these humans start competing with these wild animals for water and in most of the cases, the wild animals will be out-competed by the humans and slowly, their population sizes will go down.

The next O is over harvesting; over harvesting is harvesting beyond the capacity of a system. So, in a number of cases, we have seen that in a forest if you have a species that is commercially important, say you have a shrub or a herb that has medicinal properties.

If humans were to extract this herb or shrub in a sustainable manner, what they would have done is that they would take out some individuals and let others remain so that the next generation comes up.

But then in the case of over harvesting, what happens is there would be a few greedy people, who would get inside, remove all the individuals of this herb or shrub species and then, not a single individual is left in that area and the population declines or collapses.

The factors that drive a species towards extinction are these five factors; the loss of habitat, invasive species that have come into the habitat, pollution, human over-population and over-harvesting. Now, the impact of humans on different species is different. So, the sensitivity of a species to human impacts is dependent upon a number of factors such as the adaptability and resilience of the species.

There are certain species that produce a large number of offspring. So, even if humans are taking out individuals from this species, the individuals that remain, they breed so profusely that it hardly matters. Good examples are things like mosquitoes or things like rats and mice.

Now, humans have been trying to exterminate mosquitoes for quite a long period of time. But what happens is that every female mosquito lays hundreds of eggs. And so, even if a few individuals survive, they are sufficient to bring the mosquito population back to its original state.

This is an example of a resilient species. On the other hand, there are certain species such as elephants. Now, elephants have a very long gestation period. Elephants do not produce a large number of offspring; typically, in a birth you will only have a single calf that is produced and they also have a very long period of sexual maturity.

Now if humans remove a few elephants from the population, the population will not be able to come back. So, the impact of humans on a species would depend on how resilient the species is. Rats and mosquitoes that are very resilient; earlier the species like elephants that are not resilient. Adaptability and resilience of the species has a very important bearing on the impact of humans on that species. Next, we have human attention. So, there are certain charismatic species such as tigers which are more sensitive. Because humans have a high demand for their skin, for their bones and their other body parts.

If humans pay a lot of attention, if humans find that a certain species is beautiful or charismatic or it is majestic, then that species will have a much greater impact of human beings.

So, there is a much greater danger, if the species is beautiful like peacocks, if it is majestic like tigers and humans are giving attention to that species. So, that is a big problem. Next, we have ecological overlap between humans and the species. The greater the overlap, the greater the impact.

Now, a good example is those species that live in the plain areas. Now and especially, the grasslands. Now, humans have converted a large number of grasslands into agricultural fields.

Those species that lived in those grasslands were much more affected than those species that lived in, say the deserts, because there is a very less ecological overlap between the activities of humans in the desert and the activities of those wild animals in the desert.

Because humans typically avoid going to the desert. That is not a very good place for humans; whereas, in the case of grasslands humans find so many uses because it is a flat land, it has soil

and the land is also rich in nutrients.

It is very easy to convert these grasslands into agricultural crops. So, the impact of humans because of this ecological overlap on the species that live in the grasslands will be very high.

Next, we have the home range requirements of the species. The species that have larger home ranges are more sensitive to human impacts right. To take an example, let us consider elephants. Now elephants require hundreds of square kilometers of area for a small population.

If humans say dissect this area into two small parcels; parcel a will not be able to hold an elephant population and parcel b will also not be able to hold the elephant population. And the elephant population will slowly get wiped off; whereas, if you had a species that requires a very small area.

Again, to take an example let us consider rats. Now, rats require a few square meters of area or say a few hundreds of square meters of area. Now, even in these two patches, this patch can support a rat population, this patch can support a rat population.

So, the rat population will be able to thrive; but the elephant population will go into a decline because elephants have the larger home range requirements, they cannot live in smaller areas. But then is this threat real or is this threat imaginary and what is the rate at which we are losing out this species?

We can make an estimate by using the principles of biogeography and especially, the Island biogeography model. Now, the island biogeography model says that the species richness is dependent on the area.

If you consider an island and if you have a small sized island, it will have a smaller number of species; if you have a larger sized island, it will probably support a larger number of species. Now, the richness of the species in this island will be dependent on the area of the island.

But it is not directly proportional, it is proportional to some power of the area and we call that as z . So, we can write it as $S \propto C A^z$ where, C and z are constants.

Now, it has been found that z varies between 0.15 and 0.35. Now, taking a middle value 0.3 for an area A_1 , you will have $S_1 \propto C A_1^{0.3}$ which is 0.3, which is telling us that the species richness in this area of size A_1 is this much.

Now, even if the area decreases by as much as 90 percent. So, you only have one-tenth of the area left. Let us say that 90 percent of this island has been cleared off by human beings and only 10 percent of the area remains.

Now, how many individuals or how many species will be able to survive on this island with 90 percent of the area gone? So, if we write A_2 as 0.1 into A_1 , we will have the species richness now is $C A_2^{0.3}$ which is $0.1^{0.3}$ which is approximately 0.1.

Which means that if we take a ratio, we will find that S_2/S_1 is approximately 50 percent which is telling us that even when the area has been reduced by 90 percent, the species richness has only become half, which means that out of the complete area of the island, you have removed 10 percent only 10 percent remains.

But even in this 10 percent, 50 percent of the species that were earlier there in the island, they will find a representation; only some species that have larger home range requirements would be extinct. But now, this is just an example. If we consider what is the amount at which or what is

the rate at which the areas are actually going down.

Let us consider the tropical forest. Now, tropical forests are actually decreasing at the rate of 1.8 percent per annum. So, the rate is very small. We are not putting the area down by 90 percent, we are only reducing it by 1.8 percent every year and let us consider the lowest value of z which is 0.15.

Now, if you put both of these values into the equation, you will find that there is an annual loss of 0.27 percent. Now, an annual loss of 0.27 percent would look like a very small figure. But then the estimated number of species in the tropical forest is as high as 10 million.

So, we are having an annual loss of 0.27 percent of 10 million which is 27,000 species in a year. So, taking a very conservative estimate of the lowest value of z, we are finding that we are losing as many as 27,000 species from the tropical forest every year and this is only talking about the tropical forest.

Because the impact of human beings is there on all different kinds of habitats. We are also seeing loss of habitats, when we talk about temperate forest, when we talk about subarctic forest, when we talk about grasslands, when we talk about the wetlands, when we talk about lake strain areas,. When we talk about even the oceans because the oceans are also being dumped with so much of chemicals and waste materials, then they are also degrading in their habitat quality. So, just from the tropical forest, we are getting a figure of 27,000 species every year.

Just consider how many species we are losing when we consider all the habitats together and this figure is every year. So, we are losing 27000 species every year and the sad part here is that we will not even know what species we are losing because we have not yet documented all the species that are found in the tropical forest.

We do not know how many species of frogs are there, we do not know how many species of snakes are there, we do not know how many species of lizards are there, we do not know how many species of plants are there and this estimate is telling us that even before documentation they are losing out a number of these species.

So, the threat to these individuals is actually very large and the susceptibility of species to extinction varies. As we saw that when we are reducing the area of an island by 90 percent, 50 percent of the species remain.

What are the 50 percent that get exterminated in priority and what are those 50 percent that remain in that area? So, some species have a much greater chance of extinction, primarily because they are rare. Rarity is a function of the ecology and the and the evolutionary characteristics of the species.

And the rarer a species is, it means that you already have a very small population. Probably, it is localized in a very small area and this rarity would mean that the small population paradigm would act very fast and those small habitats, where these organisms are found, if those habitats are lost, we will lose out these species.

Now, why are certain species rare? There are three reasons. One, there is a habitat selection and evolutionary characteristics because of which a species is restricted to an uncommon habitat. Example is species that are found in desert springs. Now, in the deserts, we already have a very small number of springs.

So, a species that is localized to a spring that is found in the desert will automatically be a very rare species or species with limited geographical range such as those species that are found in a single lake. Now, it is possible that the individuals that or the species that are found in that lake, are unable to move to some other lake.

Because maybe these species cannot fly. So, they have no means of moving to another lake or those species that have low population densities, especially species such as elephants. Because larger animals require more space.

And so, because the individuals are large in size, they require large areas and a mechanism to deal with it is that these species have low population densities. Now, because this species has a low population density, it is a rare species.

Now, the impacts on the habitat or the push factors on the habitat can be accentuated by these four processes. We have the processes of habitat degradation, habitat fragmentation, habitat displacement and habitat loss.

And all four of these are different, but they have a very similar impact in reducing the habitat that is available for the species. So, let us look at these one by one. Habitat degradation is the process by which the habitat quality for a given species is diminished.

So, in the case of degradation, the habitat quality goes down. Now, what do we mean by habitat quality? Suppose, consider a lake and earlier this lake was able to support say 1000 individuals. Now, in this lake, we are dumping municipal waste and because of which the habitat quality has gone down. Now, in place of supporting 1000 individuals, it can only support 800 individuals.

Now, when such a thing happens, we will say that the habitat has become degraded; the quality has gone down, because of which this habitat is unable to support the large number of individuals and the large number of species that it was able to support beforehand.

So, it is the process by which habitat quality for a given species gets diminished. Some causal agents for habitat degradation include things like contamination; air pollution, water pollution, eutrophication, pesticides and accumulative toxins can all degrade the habitat.

Now, eutrophication is the phenomenon in which fertilizers are able to reach into water bodies. Primarily, because these days we are using a large amount of fertilizers in our agricultural fields and when it rains, these fertilizers also get washed down together with the rain and they reach into the water bodies.

Now, what happens when you artificially increase the amount of nutrients that are made available in the water bodies? So, earlier, consider there was a lake and this lake was a very good ecosystem. It was supporting a large number of fishes. Now, fertilizers have entered into this lake together with the rain water; now what happens?

These fertilizers will result in a very profuse and a very rapid growth of plants in this lake and these plants will in turn strangle the fishes and when these plants die off, then when their bodies get decomposed, then that would also result in lowering of the oxygen levels that are there in the water.

At the same time, when these plants are growing, then they are also taking up space in that water and so, the amount of space that is available to the fishes also goes down. All these processes eutrophication; eutrophication is the presence of nutrients.

In the process of eutrophication, you are putting a good amount of nutrients into the system which is having a negative impact on the habitat quality. Pesticides and accumulative toxins ah; so, pesticides can also reach into the water bodies together with the rain water and these pesticides can get accumulated in the bodies.

Now, this is an example of a Eutrophied state of a water body. So, this is the Potomac river and here, we can see that there is such profuse algal growth because the amount of nutrients in this water body has gone up.

Now, when we say bioaccumulation, what it means is that suppose we had sprayed an insecticide into the agricultural fields and together with the wind, it has also reached into other areas. It has reached into grasslands; it has reached into the forest areas.

Now, what happens? These grasses now also have a certain amount of pesticide. The insects that live on these grasses or that feed on these grasses will also eat up pesticides when they are eating of the grasses and these pesticides will in turn get accumulated or stored in the bodies of these insects, primarily in the fat tissues.

A number of pesticides are very easily stored in the fat tissues and in the bodies of these organisms, they will get accumulated and this is known as bioaccumulation. Now, what happens? The level of pesticides that was there in these grasses was very low; but now because these insects have fat bodies in their bodies, so now, the pesticide is getting accumulated in the bodies.

Now, when the next organism like frog, when it eats these insects, what happens is that the fat that was there in the bodies of these insects is now entering into the body of this frog. Now, one frog will be eating a large number of insects and all of these pesticides that were there in the bodies of so many insects, a large proportion of it will get stored in the body of the frog.

The concentration of pesticides in the grass was very less. It was higher in the case of the insects because one single insect was feeding on a large number of grasses; it is even more in the case of frogs because one frog is eating up so many insects. Then, a snake eats a large number of frogs.

And so, the pesticides from the bodies of a large number of frogs will get accumulated in the body of the snake and as we move up the food chain, we will find that the concentration of pesticides goes up and up and this is known as biomagnification. So, there is a bioaccumulation in the bodies and this accumulation goes on increasing as we move up the food chain and this is known as magnification.

A good example is the concentration of DDD in a Lake ecosystem. When it was measured, it was found that water had 0.01 parts per million of DDD. The Planktons, which are small plants, had 5 ppm.

So, there is a large increase around 500 times in the concentration of DDD that was present in water to what was present in the planktons. Then, the fishes that eat these planktons had a concentration of 40 to 300 ppm and the fish-eating birds had a concentration of 1600 to 2500 ppm.

Now, this is a very high concentration and it would have a very drastic impact on these birds and it was also found that a number of these birds, their population was declining very fast because of the presence of these pesticides, they were not able to lay eggs with strong shells.

This is an impact that occurs as we move up the food chain, the concentration of the pesticides increases and it may increase to such an extent that it starts showing up a negative influence.

Other causal agents of habitat degradation are trash. So, trash includes things like ghost nets. Now, a ghost net is a net that was earlier used for fishing; but then probably because of a storm, it just drifted out into the sea or probably it had completed its utility and so, it was dumped into the sea and you have a number of animals that get trapped in these nets. These ghost nets keep on reducing animal numbers by trapping these animals and killing these animals or we have things like entanglement. So, here you have a seal and this seal is surrounded by this piece of plastic and this plastic is cutting into its body.

Another example is this Tahr. So, we have Mukurthi National Park, where we have Nilgiri Tahrs and if you go to this area, you will also find certain trash that is there alongside the roads. So, this is having an impact of habitat degradation for the Nilgiri Tahr. We also find that plastics have entered into the areas often of a number of other wild animals such as Hyenas.

Other factors of habitat degradation include things like soil erosion. Now, when soil erosion occurs the top layers of the soil get washed away or they get blown away and when that happens the amount of soil that remains in the habitat goes down. When that happens, a number of plants may not be able to thrive in that area. So, this is also an example of habitat degradation. Another is fire regimes.

If you have a forest and there is a fire. Now because of this fire, a large number of plants can die off, a large number of animals will die off, the amount of nutrients that are available in this ecosystem will go down. So, this is another example of habitat degradation.

Another causal factor is over-exploitation of water which makes water less available for the species and deforestation. Now, we have seen this example before. If there is deforestation, then that is also degrading the habitat. And we are seeing deforestation on a large scale. So, this is an area in Balaghat, district of Madhya Pradesh in 2006.

And this is the same area in 2018 and here, we are seeing deforestation for mining operations. This is a region in Umaria district and I would like you to concentrate on this area. So, here we have a road and I would like you to concentrate on this area.

This is how it looks in 2018. So, all of these forests are now gone and this is deforestation to expand agriculture. Here, we have a region in Bhopal district in 2003. And here is the same region in 2018 to make this dam.

So, deforestation is occurring in a big way. Another causal agent of habitat degradation is desertification, which is conversion of good areas into deserts. Primarily by overgrazing and through cultural practices.

This is an image from Gujarat and when all these goats eat up this vegetation, then this area will slowly and steadily be converted into a desert. Other causal agents include draining, dredging and damming operations; in water bodies, over-exploitation of biota in which case humans go into the forest areas and extract these biotic resources out of these areas and introduction of exotic species.

When habitat degradation occurs to such a large extent that the habitat quality goes down to an extreme, then we call it a habitat loss. Habitat loss occurs when the quality of the habitat is so low that the habitat is no longer usable by a given species. So, this is the extreme form of habitat degradation.

Then, we also have habitat fragmentation. Fragmentation occurs when a natural habitat landscape is broken up into small parcels of natural ecosystems, isolated from one another in a matrix of lands dominated by human activities. It involves both loss and isolation of ecosystems.

What we are saying here is that in place of a continuous large sized area, we are dividing the area into very small parcels or pockets of land, pockets of habitat and this is known as habitat fragmentation. So, a large sized habitat is fragmented into smaller parcels.

Now, habitat fragmentation is important because larger fragments typically support more species because larger fragments have more diverse environments, more habitats, they are more likely to have both common species and uncommon species.

And also, because these smaller fragments have smaller populations, the chances of them getting extinct are greater. Because if you have smaller populations, then the small population dynamics also start acting on those small populations. So, it is always beneficial that we should have habitats as big contiguous areas and not as small parcels.

Now, how does habitat fragmentation occur? The causal agents include things like roads, railways, dams and other structures and structures such as these linear infrastructures of roads and railways, they not only cause mortality, they act as a physical barrier because of which the animals are not able to cross them, they act as psychological values.

If you consider a road in which there is heavy traffic, the animal, if it wants to cross to the other part of the habitat, will not be able to do that. Because of the fear of getting hit by one of these vehicles. So, either this animal gets hit or in certain cases it is so afraid that it does not cross this area because it acts as a psychological barrier.

Then, these structures such as roads and railways also increase the access to human influence and they increase access to invasive species and exotic species. Other causal agents for habitat fragmentation include diversion of land for agriculture. So, here we are seeing linear infrastructure in the form of pipelines.

If you have such pipelines, animals find it very difficult to cross from this area to this area. If you have a dam an animal will not be able to cross just like this. It will have to either cross a very long stretch or it will just not cross this area. So, dams cause habitat fragmentation.

Now, the process of habitat fragmentation and loss occurs in a series of steps. So, we will understand these steps through these illustrations. Let us consider that this is an original forest and you have a line number of trees here.

Now, the first step that occurs is Dissection. In dissection one or more linear infrastructures, primarily roads are set up and these roads dissect this complete forest into two or more smaller parcels. Now, once this dissection has occurred, it is now easier for humans to come to these areas and so, we will start seeing small settlements.

Now, in these small settlements, people will start farming these areas or raising some certain livestock and to make space for farming and for livestock, they will clear up certain portions of the forest and this is the stage known as Perforation. So, now, they are perforating into the forest. So, this is how it will look like. These are livestock in the forest near the Mudumalai Tiger Reserve.

Now, after perforation, once you have certain human beings that are living there in the settle-

ments, these settlements slowly grow and why do they grow? Because they are right next to the door and any produce that these farmers or these early settlers produce in the form of milk or say agricultural produce, it finds a ready market because people who are going through these roads will buy their stuff.

Slowly and steadily, the number of livestock will increase, the area under cultivation will increase, more and more buildings will come up and in this process, it is now converting this whole forest into smaller parcels. So, this is one parcel; this is one parcel; this is one parcel and this is one parcel. So, we now have four small parcels. So, this is habitat fragmentation that is happening.

This is an example of habitat fragmentation. So, these early settlers have now converted all of these areas into their agricultural or plantation areas and so, the animals that were there in these forests are now unable to cross these areas and so, this has become a small fragment.

After fragmentation, we will have the process of Attrition. Now, in the process of attrition, these settlements grow to such a large extent that these pockets have now become very small areas and during this process of attrition.

We will also start seeing electricity coming into this area or small industries coming into this area or certain facilities such as schools and hospitals that are being built up. Because now, these settlements are so large that the government is bound to provide them with certain facilities.

And so, with this process of attrition, we have very small parcels that are left. This is an example. So, this was a beautiful hill that was covered with forest, but now through the process of attrition, we only have this small patch of forest that is left in this area.

Now, we can see an example through the deforestation of the Amazon rainforest. So, these are satellite images from 1975 and I would like you to pay attention to this road. So, this is how the dissection occurred in this area. So, this road was constructed in this pristine forest.

Now, this is 1975; this is 1984. So, by 1984, people have started to enter these areas and they have constructed a new road. So, we did not have a road here, but now you see very clearly that this stream has also been converted into a passageway and now, deforestation is occurring in the form of this fish bone pattern.

So, this is 1984, 1985, 1986, 1987 and we see that slowly and steadily the forests are being converted. And the wood is being extracted out. 1996-98, 2002, 2007, 13, 15, 16 and so, what was there in the form of a pristine forest is now completely deforested.

What started with a small amount of habitat degradation and habitat fragmentation, ultimately resulted in the loss of the forest. So, before we have a situation like this a pristine forest. Afterwards, we hardly have any forests that are left in this area.

And this is an example of an extremely fragmented habitat from Mudumalai. So, this area is a part of the elephant corridor. So, elephants traditionally use this area to move from one place to another place. But now, with the settlements, we can see that these hills still have some forest left.

But the rest of the place is now completely converted into a human dominated landscape and in such landscapes, people set up fencing and because of that animals are unable to cross into these landscapes and the hills that are left are so high that the elephant will not be able to cross through

this landscape by going through the hills.

Because it is a very massive animal, it has a weight of like 4000 or 5000 kgs and it takes a tremendous amount of energy to lift that huge weight through gravity on top of these hills.

So, animals do not prefer going like that and so, this has resulted in a fragmentation in this area. Now, apart from habitat fragmentation, we also find another phenomenon which is known as habitat displacement. Now, habitat displacement is the shifting of wildlife to non-prime or sub-prime habitats such as hills or rocky patches.

Now, what is habitat displacement? Now, typically if you go to any grassland area that is near a forested area and if you find that people are taking their cattle into these grasslands and if you ask these people that- 'oh, your cattle are out competing the wildlife', they would normally say- 'oh, no, this is not the case because our cattle graze in these grasslands; whereas, the wild animals live on top of the hills.

Now, if you think about it logically, the wild animals do not live on top of the hills because the wild animals also require the same resources, they also require access to the same grasses, the same fodder, the same water that is being used by the cattle. But then, because of a tremendous competition with the cattle.

Because together with the cattle, there will be humans who will be going into these areas with their and probably, they will also be taking a few dogs and so, the animals have been displaced out of these grasslands.

These animals do not have any other place to live than the top of the hills. So, the animals have been shifted from their prime habitats to a non-prime or subprime habitat. Now, why are these hill areas non-prime or subprime habitats?

Because they do not have a sufficient amount of fodder, they do not have a sufficient amount of water and so, they are subprime habitats and in this process of habitat displacement.

The the wildlife has been shifted from a prime habitat to a sub-prime habitat such as hilly or rocky patches and because these sub-prime habitats do not have sufficient amount of food and water and other resources for the animals, so slowly and steadily there the the population of the wildlife will go on decreasing because the habitat does not have sufficient canal capacity.

These are all different threats to the species. So, we looked at the large population dynamics, we looked at the small population dynamics and we looked at processes of habitat degradation, habitat loss, habitat fragmentation, habitat displacement and so on. These are all the threats that our wildlife are facing these days.

That is all for today. Thank you for your attention. Jai Hind!

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Module 4
Threats to wildlife
Lecture 3
Ecotoxicology and Developmental Hazards

Namaste!

We carry forward our discussion on the Threats to WildLife and in this lecture we will have a look at Developmental Hazards and Ecotoxicology. Now you must have heard in a number of circumstances that we are aiming for economic growth and are aiming for economic development. The question is are both of these the same or is there a difference between economic growth and economic development.

Let us look at what growth and development mean, growth is an increase in size of something or increase in the level of output of something. For instance if you see that there is a child and the child over the years is increasing in height it is increasing in its weight, then we would say that the child is growing because there is an increase in size of something.

Similarly when the economy grows it means that the economy is increasing in size, the total amount of income that we are having or the total resources that we are having are increasing with time. When that happens we will say that an economic growth is occurring or an increase in the level of output of something. So, for instance there is an industry that is producing say 100 cars in a day and because of some technological changes or because of certain managerial decisions this output increases to 250 cars a day.

In this case the level of output of the industry has increased and so we will say that the industry is showing a growth and if a number of such industries show a growth we will say that the automobile sector is showing a growth. So, growth is an increase in the size of something or increasing the level of output of something.

This is different from development. Development is the process by which the economic well-being and quality of life of a nation, region or local community are improved according to targeted goals and objectives. Now when we are talking about development we are not talking about an increase in size of something, we are talking about things which are wellbeing, we are talking about things which are quality of life.

Similar to our child example when the child is increasing in size or increasing in height we see that the child is growing. But, then when the child learns something new when the child has started to learn the alphabets. When the child has started to walk or has started to talk then we say that the child is developing. So, there is a difference between growth and development.

Growth is an increase in size, whereas development is an increase in wellbeing or an increase in the capabilities.

In the case of economic development we are talking about the economic wellbeing of a nation, region or local community. We can look at development at different scales. We look at development at the scale of a nation or region or a local community. But when the economic well being increases and also the quality of life increases, then we say that there is an economic development.

We generally consider 3 dimensions of economic development or human development, these are the life expectancy index which is how many years can a person or a child that has just been born can expect to live. So, if for instance there is a society in which sanitation is good everybody gets adequate nutrition and health care is good, then we will see that the life expectancy increases.

And when life expectancy increases we will say that the development has occurred, because there is an increase in the quality of something. Similarly, education index: how much a person can expect to receive in terms of education. If people are literate then they are said to be more developed, if people go to colleges, if they go for a post graduation course we will say that they are more developed than say a person who is illiterate.

Because, education gives you the capability of doing something, so it increases the wellbeing and it increases the quality of life. So, the Education index is also another component of development. Income index: how much income do people receive and what is the level of equality or inequality in the society, when we talk about income index we look at how much can a person expect to earn.

And also what is the level of income inequality in the society, because for instance there is one person who is earning a lot and a majority of people are not earning anything. So, in that case the average income will be high, but because of income inequality we will say that this society is less developed, than perhaps another society where everybody has a similar level of income on an average.

These are the 3 dimensions of the human development index. Essentially what we are saying is that when we talk about economic growth we are talking about an increased output and an increased concentration of resources. But when we are talking about economic development then we are talking about how much is the wellbeing of people, how much is the capability of people to have a control over their lives, so that is economic development.

Now both of these are related, but there is also a trade off. For instance if you want to empower people, this empowerment can be taken as an indicator of development because, when people are healthy, when people are educated and when people are financially capable of doing things, then they are more empowered than when people are unhealthy or they are illiterate.

So, empowerment is a proxy that we are using here for economic development. Production is another proxy that we are using for economic growth, what is the amount of production that an economy is doing? Now this curve is telling us about a trade off between production and empowerment. Suppose society decides that we are going to invest our resources into producing more and more stocks.

In that case the empowerment might take a hit, because the people who were necessary for doing empowerment such as doctors or nurses or teachers that would have helped people to have a much better control over their lives are now being diverted into say production.

In that case we will or this society will have a much greater production, but at the cost of empowerment. The society might even take another decision that empowerment is more important for us and so we are going to divert certain resources from the production sector and we are going to put them into the empowering sector. So, for instance we will take out the best managers that are there in the industries and we are going to put them into academics.

When such a thing happens then we will say that the society is focusing on empowerment. Now a curve such as this represents the production possibility frontier. Now it shows us that there is a trade off that needs to be made between production and empowerment and different societies face choosing different things and in a number of cases it might be difficult to have in excess of both of these at the same time. It is possible it is what we are aiming at, but at times there has to be a choice that needs to be made.

When we talk about economic growth we say that the production is increasing. So, this is how the production possibility frontier will look like when the production increases. Now when the society shifts from the black curve to the red curve then the amount of production in the economy has gone up, but the level of empowerment has not changed.

Probably people are still illiterate, people are still unhealthy, but there are some people in this society that have become richer. So, this is an example of economic growth without any amount of empowerment to the society. Another example is this one where the amount of production remains the same, but the society is only focusing on empowerment. So, in this case everybody has become more capable of having control over their lives, the empowerment has increased without the economic growth.

But in a number of cases what we are aiming at is an increase in production as well as an increase in empowerment. So, there is economic growth, but there is also economic development. Now, why do we require both of these together because we are as a society we are aiming at economic development which is increasing the wellbeing of people.

Now the well-being of people will not increase if they do not have access to stuff. So, to increase their well-being you have to provide them with more resources. So, if there is a society where everybody just has one board of transportation which is walking, then probably they are less empowered than say a society where everybody has a bicycle or say everybody has a car.

To empower people to move from one place to another in a faster manner we will have to provide them with bicycles or cars and this is only possible if there is a production of bicycles and cars. So, for development we want to increase production, but at the same time we also want to increase the level of empowerment that is there with everybody.

So, you need to devote resources to ensure that people are educated and people are healthy. For instance if this if our society just wanted to produce more and more cars and it led to such a huge amount of pollution that everybody in the society became ill. In that case we will say that there has been an economic growth, but at the cost of empowerment and so we will not say that the society has developed economically. So, there is no economic development even though there is

growth. So, this is a distinction that we need to keep in mind.

However in a number of cases what we have observed is that if there is an increase in production people say that the economy has developed. Whereas, in reality we are only having economic growth without having any development, now this distinction needs to be kept in mind before we move further.

What happens when we only focus on growth we do not focus on development or in other words what are the hazards of focusing just on an unsustainable growth. Now remember that when we talked about development we were talking about the wellbeing of people, now the wellbeing of people increases when they have access to nature. The wellbeing of people increases when they live in an area or in a society that has less levels of pollution.

The wellbeing of people increases when they have the joy of watching wild animals such as tigers. So, if we remove all these well beings, if we just provide economic growth and to provide the economic growth we put people into a condition where they have or where they are forced to live in very polluted areas where they are forced to live in a society, where the biodiversity is all gone where the children have never observed a butterfly or birds then probably there is something that is going wrong.

When we focus only on unsustainable economic growth there are a number of hazards that are proper. Now remember here that these are the hazards of going for an economic development which technically should be called only as an economic growth, because these are reducing the wellbeing of different people.

What are these hazards? These results include the loss of biodiversity. So, in this image what we are observing is that there is this net that was used for fishing and to increase the production of fishing we have increased the production of these nets or probably we have subsidized these nets. So, there is an excess of these nets.

Now, if there was not an excess of these nets if they were scarcer, then what people would have done is that if the nets went bad if there was say a cut in the net people would have tried to mend it. But if you can get these nets very cheaply because of the economic growth, what people do is that they do not or they are not incentivized to mend the net, but they go for a disposable culture. In this case what people would do is that if there is even a small cut in the net they will throw this net off and buy a new one, because the economic growth has made it possible for them to get another net very quickly. So, what happens to the previous net? It will be thrown into the rubbish dump and suppose it goes to a landfill and because most of our landfills are already filled up.

It is washed away and when it gets washed away it reaches into a water body. Now the net was designed to capture animals and in this case even though there are a few cuts in this net this net is still capable of catching animals. So, this is an example of the hazard of having economic growth without development.

Because if there was development, if people were made more aware of what are the negative impacts of doing this fashion then probably they would have refrained from throwing this net out they would have disposed of it more properly. But if there is no development if there is a lack of awareness or education then this is what happens. So, one hazard is the loss of biodiversity.

We are observing all over the world that a number of animals are dying, they are getting entan-

gled in these pieces of plastic and they are dying off. And when there is a loss of biodiversity this also reduces the wellbeing of quite a number of people, because biodiversity has its own advantages.

Now, the people who live in the cities might be less aware of the advantages of biodiversity, but then if you talk to anybody who works in say an apple orchard he or she will tell you the importance of honeybees. If the honey bees are gone there is nothing that can pollinate the apple orchards and probably the production would go down. So, the loss of biodiversity is a hazard of unsustainable growth.

Another hazard is trashing the planet: you go to even a national park and you will find that there is trash all around. There is plastic that has released into a majority of areas our wildlife are now living with the trash and we are trashing everywhere we are trashing the water bodies, this trash is coming to the beaches we are even trashing the seafloor. So, trash or trashing of this planet is a hazard of a development or an economic growth that is unsustainable.

Another is Clearing a forest because for economic growth you require resources, resources such as land resources such as wood resources such as pores and minerals that are there in the land. Now to have access to all of these there has been a rampant cutting of trees and rampant deforestation which is another hazard of unsustainable economic growth.

This is an example of deforestation for mining. So, this is Balaghat in 2006 this is the same area in 2018 the forests are gone this is an example of going for an economic growth because of which people are diverting the forest into agriculture. So, this was Umaria in 2002 and if you concentrate on this area it is gone. All of these forests are now gone, so this is the Umaria in 2018.

This is a portion of the Brazilian rainforest in or the Amazon rainforest in Brazil Rondonia in 1975 and this is the same place in 2016 the forests are all but gone. Now, why are we seeing this rampant deforestation, this is because we are focusing only on economic growth and the cost of wellbeing of people.

If you talk to the local communities in Brazil a number of these communities are up against this rampant deforestation because it is encroaching upon their lands, it is encroaching upon their culture, it is encroaching upon their way of living. But for an unsustainable economic growth the governments are permitting these things to happen or they are unable to stop people from doing this.

This is another example of deforestation for mining. This is the Ok Tedi Mine and if you concentrate on this area or if you concentrate in the river where the dumps are, there is now a massive amount of deforestation. So, this river has become so toxic that the trees around it are dying off.

Another hazard of unsustainable economic growth is desertification and overgrazing. Now, in the case of economic growth we wanted to increase production. So, every farmer wants to have more and more milk. Now if the farmer wants to have more milk he or she will want to have more goats, but then this environment cannot sustain such a huge number of goats.

What do these goats do? They eat off all the grass they eat off a majority of the herbs and shrubs that are there in this area which leads to an expansion of the deserts. So, this is overgrazing, overgrazing why because the people are going for unsustainable economic growth.

We are also observing a large amount of fragmentation of the habitats. So, there is this road where you have forest on both sides, if the animals want to cross from here to there they are unable to do that because there is a road in between and if the animal tries to cross it may get hit. And this extreme fragmentation of the habitats is also another hazard of unsustainable economic growth. Another hazard is what we are observing in terms of climate change. So, these are bleached corals because of climate change. So, all of these corals, these beautiful organisms, are now dead.

Because of unsustainable economic growth we are spewing out. So much greenhouse gases such as carbon dioxide that the earth's temperature is rising. It is impacting the coral reefs it is impacting the coral bears whose habitats are now going down. There are a number of instances in which the eye sheet has become so less, that now these polar bears do not have a place to rest.

Climate change is impacting the mangrove forest climate change is impacting the kelp forest in our oceans. We are seeing a large amount of habitat level destruction because of climate change and what is causing this climate change. Economic growth is unsustainable economic growth, so this is also another hazard that we are observing.

We are observing changes in the spatial distribution of organisms. The organisms that were living in colder areas now because of an increase in temperature are dying off, because they cannot tolerate that amount of heat or those areas that were. So far inaccessible by certain organisms they are now getting colonized. So, there is a change in the special distributions of different organisms. This is also because of global warming which is occurring because of an unsustainable economic growth.

Another hazard is wars. Why would 2 countries go for a war? Because each country wants to increase its resources for economic growth and because there is a limit to the amount of natural resources that are present within any country. There is a limit to the amount of land that each country has. They try to attack someone else to capture their land to capture their resources and that leads to war that leads to a heavy destruction of the environment. This is another hazard of unsustainable economic growth.

The trash that we are putting into the environment, even if it gets degraded it is still trash. So, we have smaller fragments of plastics that we are finding everywhere. And there are a number of organisms that mistake plastic for their food, these plastic bags look like jellyfishes.

So, an animal that eats jellyfishes might attack these plastics might try to eat these plastic, we have seen instances of birds where the parents bring in plastics to feed their chicks mistaking these plastics to be fish and because of that the full of the alimentary canal of this bird gets choked and this bird dies out of starvation. Loss of biodiversity in this way is also a hazard of unsustainable economic growth.

We are seeing it everywhere, even deep in our oceans. We are finding that the plastics have reached, there they are impacting all organisms whether big or small even in the case of microscopic organisms we are finding that their bodies are now filling up with plastics.

The behaviours of organisms are changing. So, this is another hazard of unsustainable economic growth. We have trashed the planet to such an extent that now the organisms are getting more and more accustomed to these plastics, they are now using these plastics and showing the behav-

iour that is not a natural behaviour. So, this loss of natural behaviour is also another hazard that we are observing

This image of a seahorse that is sticking to an ear bud or these animals, these hyenas that are living in trash or these rhinoceros that we are finding full of plastic. Now a Rhinoceros in a natural environment does not eat plastics, but we are changing the behaviours of animals by trashing our planet. So, this is another hazard of unsustainable economic growth.

Now, in the quest for having more growth in the quest of having more production we have produced such a huge quantity of plastics that now it has turned into a menace. Changing behaviours of different animals here we are observing that now everybody has access to roads everybody has uh is having big cars and this interaction with wild animals is changing their behaviours.

Now there is a greater interaction of people and animals we are finding that we have developed or we have constructed. So, many roads that now they are acting as big barriers to the movement of wildlife wild life is. Now finding it more and more difficult to cross the road. So, earlier this whole habitat was this, but now we have divided it into fragments.

If they try to cross they might get hit, they get killed or even otherwise there is a huge structure in their habitats. So, these are all different hazards of unsustainable economic growth pollution because of the heavy amount of vehicles that we are flying on the roads.

Now having more vehicles we will obviously say that yes that is economic growth, but is pollution leading to the welfare of people of course not. We cannot say that we are developing economically if these negative impacts are not checked. So, pollution is another hazard of unsustainable economic growth.

There is also a huge number of deaths of birds, because they are getting collided with a number of our infrastructures and the birds are dying. So, that is not leading to the welfare of people that is not development. So, we are just aiming at economic growth at the cost of welfare and that is a big hazard.

We are changing the distribution of species because of our trashing the planet, more and more invariant species are now able to reach more and more areas. And this is an issue not just for animals, but this is an issue for humans because ultimately the wellbeing of humans is getting impacted because of these conflicts because of the trashing of the planet.

What we can say is that if you go for an unsustainable economic growth there will be a huge number of hazards, hazards of pollution, hazards of fragmentation, hazards of loss of biodiversity, hazards of increasing conflicts with wild animals and that is not leading to a welfare for the society. That is not development, that is just economic growth at the cost of development. So, this distinction - this fine point needs to be kept in mind whenever we are doing any economic analysis.

Next we will have a look at Ecotoxicology which is the study of the effects of toxic chemicals on biological organisms especially at the population, community, ecosystem and biosphere levels. Now the point is why do we need to study Ecotoxicology. So, this is important because we are releasing a huge quantity of toxic substances into the environment and they are having an impact on different organisms at the individual level. Sometimes at the population level and sometimes at the even greater higher levels.

Now, the common toxic chemicals that are present in the environment include pesticides and their residues. These days, because of the need for more and more quantities of food grains we are using a heavy dose of pesticides. Now these pesticides kill the pests such as insects or rodents, but whenever these pesticides are used and they are toxic chemicals some portion of them is always leaked out into the environment and it remains in the environment.

Even though there might be certain processes, certain chemical reactions that will change these pesticides, some of the residues will remain in the environment and that will create a condition that will have an impact on certain organisms. So, Ecotoxicology studies the impacts of pesticides and their residues and we will have a look at what these impacts are in a short while. Heavy metals: heavy metals especially those that we are releasing because of our mining activities such as in the case of tailings dam.

This is an image from Balaghat. So, we have a mine there and this is a tailing dam. Now in the tailings dam the residues that are released from the mine are stored and we can observe that in this satellite image from 2006 we can observe so many trees that are there in between this fake tailing dam.

This is another image from 2018, so we can see that if you concentrate in this area we had trees here in 2006 and in 2018 these trees are gone. Now uh similarly if you consider this section, so we have trees till this line in 2006 and by 2018 that these trees are gone.

Now, nobody is going into a tailings dam to cut these trees, but what is happening is that because you have a heavy concentration of heavy metals. So, that is creating a toxic impact on these trees and these trees are dying off. So, heavy metals and their release and their impact is also something that we study in Ecotoxicology

Plasticizers, so whenever we talk about plastics plasticizers are the chemicals that are added to plastics to modulate their properties to make them more elastic or to make them a little transparent or to improve their properties these are the chemicals that are added to plastics. Now a number of these chemicals have toxic impacts such as this chemical bisphenol-A.

Bisphenol-A is a plasticizer that is added to plastics to make it more supple to make it more transparent, but it acts like hormones in the bodies of different organisms. It disrupts the functioning of the endocrine system in different organisms and Ecotoxicology will try to study what is the impact of this chemical on different organisms at different scales or volatile organic compounds such as formaldehyde.

The formaldehyde is released as part of a number of chemical reactions and it is a toxic chemical or mycotoxins. Now mycotoxins are toxins that are released by different fungi. Myco refers to a fungus and mycotoxin is a toxin that is being created by a fungus. But what is happening is that because we are changing the environment to such a large extent. So, we are increasing the amount of mycotoxins that are present in the environment.

What is the impact of these mycotoxins on different organisms is also something that Ecotoxicology will try to decipher. Or the impacts of things such as Brominated flame retardants. Now these Brominated flame retardants are added to a number of plastic products to reduce the probability that they will burn up in case a fire occurs.

Now, these Brominated flame retardants are bioaccumulative toxins they accumulate in the bod-

ies of different organisms and in this manner they are able to concentrate themselves and then have a larger impact on different organisms at different levels.

Now talking about toxicity, all of these chemicals will be having different levels of toxicity. Those chemicals that have an oral lethal dose which means what is the amount of any chemical that when given to an organism in the oral route - which is through food or water - will result in a lethality that will kill the organism.

This is the oral lethal dose it is generally expressed in terms of milligram per kg body weight of the organism. Now if there are chemicals which are lethal or which kill the organism at as low as 1 to 50 milligram per kg, then we say that these are the most poisonous chemicals and whenever they are being transported this is the symbol that is used.

If the oral lethal dose is between 51 and 500 milligrams per kg we still call it a poison but it gets a yellow layer. If the oral lethal dose is between 501 to 5000 milligrams per kg it gets a blue label and to be call it a dangerous chemical and in case the overall lethal dose is greater than 5000 milligrams per kg we put the label which is green in color and we say that this is a chemical that we need to be cautious about. So, different chemicals have different levels of toxicity and of course those chemicals that have a higher toxicity will have a much greater impact which will be an acute impact.

Now, an acute impact means that the impact of this chemical on the organism or on its population or community will be quick. That is known as an acute toxicity, an acute impact or a quick impact. It generally occurs in a very short period of time because of a very sudden exposure.

In the case of those chemicals that have less amount of toxicity in a number of places they will observe a chronic toxicity, which means that if these chemicals are released into the environment they will slowly act and produce their side effects. So, it will act over say many months or many years and in that case we will say that it is a chronic toxicity which occurs over a large period of time.

Now, what are the impacts of these chemicals? In very high doses these chemicals will have lethal effects which means that they will kill certain individuals or a large number of individuals in any population or community. So, this is known as a lethal effect in certain cases we can have sub lethal effects in which case the organisms do not die, but they have a reduced amount of functioning.

That is a sub-lethal effect certain chemicals are mutagens which means that they produce mutations in the genetic code. So, we have chemicals that produce mutations, so they have a genetic effect on organisms. Certain others have Teratogenic and developmental effects, now teratose means a monster and genesis means production.

Teratogenic chemicals are those chemicals that are monster producing which means that if the organisms are exposed to these chemicals and especially those organisms that are pregnant. So, these chemicals will act on the fetus and will produce developmental abnormalities which means that you might observe that there is a frog which in place of having 4 limbs is having say 5 limbs or 6 limbs or there is a tortoise that is born without limbs.

Now, these kinds of organisms can be produced because of Teratogenic chemicals or developmental inhibitors. In certain other cases we observe a reduced fecundity which means that the or-

ganisms will be having less number of children or less number of offspring. So, this is a reduced fecundity that you observe in a case of a number of toxic chemicals and especially the chronic toxins.

They manifest their impact in terms of reduced fecundity. This is possible because in certain cases the offspring when they are there in the fetal state they will die off or there will be spontaneous abortions, because of these chemicals and so the fecundity will go down and in any case these toxic chemicals add to the existing stressors. Which means that if the organisms are weakened because of a disease or because of malnutrition and if they also are exposed to these toxic chemicals in the environment the impacts add up. So, they act to the existing stressors that are already there in the environment.

What is the impact of a chemical such as DDT, now DDT is a pesticide which was traditionally heavily used for agriculture and it was also used in the control of malaria. Now when DDT is used as a pesticide a portion of it remains in the environment. So, when DDT is used in an agricultural field to kill off insects that were destroying the crops with the next screens a portion of it may get washed off and beat into a water body. Now DDT may be acted upon by oxygenation or because of certain organisms and it gets converted into another residue which is known as DDT or DDE so dichlorodiphenyldichloroethane or ethylene.

Now, these chemicals are very persistent chemicals that remain in the environment for a very long period of time and they can show their impacts on different organisms. Another characteristic of these chemicals or these residues is that they accumulate in the bodies of different organisms and as we move up the food chain their concentration goes on increasing because of a process that is known as bio magnification.

If you look at the DDT or DDE concentration in the water it will be very less because it is only a small fraction of the residue that came to the water body and the concentration in plants or say the phytoplankton again will be very less, but the zooplankton they eat these phytoplankton will have a greater concentration of these residues in their bodies.

The fishes that eat up these zooplankton will have an even greater concentration of these chemicals in the in their bodies, because what is happening here is that all the the zooplankton that the fish was eating they were having certain concentration of these residues in their bodies and the residues from all of these zooplankton will now get accumulated into the body of the fish. So, the concentration increases.

Those fishes that eat up these smaller fishes will have an even greater concentration, the birds that feed on these fishes will have an even greater concentration. Now what happens is that when the concentrations increase the impact of the chemicals or the toxicity of the chemicals also starts playing a role, because as we have seen there is a lethal dose for different and in between it will start doing certain sub lethal effects.

So, in that case the organisms will not die, but will show impact in terms of reduced fitness or reduced fecundity and this is what was observed in the case of Bald Eagles. Now, Bald eagle is the natural bird of the United States and it was found that when the researchers looked at the concentration of DDE in the egg shells.

This curve is showing the DDE concentration on the x axis and the average 5 year productivity

that is the number of eggs or the or the number of chicks that were that were born in every generation on the y axis. Now, this is the average of the curve, this is the regression curve, the sigmoidal regression curve and here we can observe that if the concentration of DDE is less than or equal to 2 microgram per gram then there is hardly any change in the average fiber productivity of these birds.

If the concentration of DDE is greater than 20 microgram per gram in the egg, then we observe that the average 5 year productivity is very less. It is close to 0.1 that is roughly one tenth of what we see in the national conditions. And in between we see that this curve slowly goes down which is telling us that as the concentration of these residues increases the average 5 year productivity or the fecundity of these birds decreases

Now, it was later found out that because of these residues the egg shells that are formed are very thin and they are so thin that when the bird sits on these eggs the eggs break, which reduces the productivity of these birds. So, this is the curve that is telling us that as the concentration of these residues increase they start showing a more drastic impact as was shown or was shown when the concentrations were lesser. And because these chemicals are very persistent chemicals and so these impacts can be shown for a very long period of time.

But then we still have hope because a number of these populations are also resilient. If you look at this curve on the x axis we have the years and DDT was banned in the year 1972 in the United States and when before this ban the this line is showing us the DDE concentration in terms of ppm of dry weight and the average concentration was close to say around 100 ppm.

After the ban it took a few years but then the concentration came down to around 30 ppm. Now remember that here the concentration has not gone down to zero because it is a persistent chemical, but the concentration has come down. Now before the bank the mean number of young for breeding area was 1.3 and then because of the impact of DDT it was coming down. So, from a natural level of 1.3 it had come down to around 0.5.

But then when this ban was enclosed, so slowly and steadily the concentration of DDT went down and the residues such as DDE also went down and after a while we see that this curve is now increasing. So, the mean number of young per breeding area they are now increasing from 0.5 they have reached to around 1.1 they have not yet reached to 1.3 but they have reached to 1.1.

Now, this is showing us that even in the case of a number of these persistent chemicals, if we enforce a ban then there is still a possibility for a number of species to come back. Now this coming back is known as resilience and this curve is also telling us why it is important to study the impacts of these different chemicals, because only when we know their impacts will we be able to act upon them.

Now, such a recovery can also be aided through certain activities that are known as restoration and this comes under the domain of restoration ecology. So, restoration ecology is the scientific study supporting the practice of ecological restoration which is the practice of renewing and restoring degraded damage or destroyed ecosystems and habitats in the environment by active human intervention and action.

It is telling us that even when we have damaged the ecosystems and habitats. So, they are now

degraded, damaged or destroyed. In the field of restoration ecology we try to put in active human intervention and action and we try to bring them back to their original state. We are aiding in the restoration of these damaged habitats. There is damage that has already been done, but through restoration ecology we are trying to bring the system back to that.

How do we do that we have already released a heavy amount of toxins, we have already released a large quantity of plastic. Is there anything that we can do and if yes what are the steps that we can do? What kinds of actions are done? So, there are certain actions that degrade the environment and there are certain actions that restore the environment.

Degrading actions include things such as precision of prescribed burning. If you do not perform prescribed burning, your grass will be taken over by trees which will be a change in the local system, which will be having a degrading impact.

Cultivation and cropping in a number of cases degrade the habitat, disturbance, excavation or burial or substrate things it is mining. Eutrophication - Eutrophication is excessive nutrients being made available to the system, especially the water bodies because in a number of cases the fertilizers get run off from the fields into the water bodies.

Disruption of hydrology by say construction of a dam invasion by non-native species, especially the invasive species, logging of trees that is cutting off of trees overgrazing, removal of animals by poaching and contamination of soil, so these are all different examples of degrading actions.

Restoration actions could include things such as cessation of the degrading action. So, in case you were doing say poaching in an area, then a restoration action would be to give up poaching. But this is a passive restoration in the case of active restoration you will also reintroduce the animals into this area to make up for the population loss.

Another action is extirpation of the damaging species. So, if there is a non native invasive species you will remove that species. So, that will be a restoring action that will help the system come back to normal more quickly. Nutrient removal in cases where you already have eutrophication, you may try to remove certain nutrients to remove the negative impact planting of grasses and grass like other herbs or pops.

Especially in those areas where you have done an excavation if you plant grasses then the soil will get stabilized or planting of trees or reinstatement of burning if you were not doing the prescribed burning that is the restoration action. The remodelling of topography especially in cases where you have already dug a huge exclamation pit or where you have already created huge amounts of waste.

In that place remodelling of the topography to ensure that these waste do not get washed away, that is restoration action or soil amendments to bind or to dilute the contaminants how to restore the fertility. These amendments can be done in space where there has been heavy erosion. We may try to increase fertility. In cases where there are contaminations we may try to wash away the contaminants to reduce their concentrations. These are all different examples of restoration activities.

Now, it is important to keep in mind that the restoration has certain constraints, as we have seen before there are always tradeoffs and in the case of restoration we need to keep in mind the regional constraints and the local constraints. For instance in certain cases it may not be possible to

bring the system back to its original state. We may try to bring it to a state which is a bit better or maybe a bit different from what was there originally, because there are certain constraints at the local level and at the regional level.

Probably the carnivore that was removed or was made locally extinct because of poaching that is no longer available. So, in that case you may try to reintroduce some other carnivore to stabilize the system. So, the constraints have to be kept in mind.

Now we will look at a few examples in the case of mining. If mining was done then a lot of degradation activity had already taken place. Deforestation because to access the earth we remove the trees that are there, because these trees have been removed there will be soil erosion. In the case of mining there will be a certain amount of heavy metals that will be released that will lead to water pollution.

So, anyway metal releases water pollution. Soil erosion and deforestation are all different kinds of degrading activities or degradations that have already occurred in a mine. The restoring actions could be things such as flattening of waste dumps and landfills to prevent erosion, filling up of the duct pits covering with a layer of clay to prevent access to rain and oxygen, covering with a layer of topsoil because there because of the heavy erosion the topsoil is gone.

We cover it with a layer of topsoil and plant trees or evaporate tailings dams, so that the water is removed, the waste gets concentrated and then it can be removed from the area, so these are examples of restoration activities. Similarly, in the case of river systems we can have degrading actions such as construction of dams.

A dam completely changes the hydrology of the area. From a running water system you have converted the area into a stagnant water system. So, that causes a change in the hydrology, it changes the movement of different organisms such as fishes.

Other examples include diversion of land. So, land that was there in a flood plain has now been diverted and made into, say a building area. Overuse of groundwater, channelization of streams - these are all different things that lead to changes in hydrology.

Then we have changes in the habitat clearing of land grazing especially over grazing, mining in the area introduction of the invasive species. These are all different kinds of degrading actions. Restoration actions would include things like restoring the hydrological processes and the geomorphic features. If the floodplains have been diverted into construction areas then probably some of these have to be brought back into the flat plains.

Restoration of the riparian vegetation, so in case certain invasive species have invaded into the area then they will have to be removed and the natural indigenous riparian vegetation will have to be brought back. That will be a restoring action, restoring of animal life that was affected because of the degradation.

And when we are doing restoration activities these days bioremediation has come in a big way to aid the restoration activities. Bioremediation is the process that is used to treat contaminated media including water, soil and subsurface material by altering environmental conditions to stimulate the growth of microorganisms and degrade the target pollutants.

What we are saying here is that this is a process used to treat contaminated media. For instance there was an oil spill and the oil has been leaked into a water body. Now this oil is bringing up

certain toxic impacts. Now to treat this oil we can either make use of dispersants such as detergents or you can make use of bioremediation.

In the case of bioremediation what will be done is that the microorganisms that can eat up these oil spills will be introduced into the area and probably certain nutrients will be added to the area to promote the growth of these microorganisms. And when you have these microorganisms they will act upon the oil and they will eat up the oil, so this is an example of bioremediation.

It is a process used to treat contaminated media including water, soil and subsurface material by altering environmental conditions. Now in this case an altering environmental condition is introduction of the nutrients, so that the microorganisms are able to grow. So, you alter environmental conditions to stimulate the growth of microorganisms and degrade the target pollutants.

Another example is phytoremediation, in which case we make use of those plants that can treat the pollutants. So, a good example is the treatment of municipal waste. So, the municipal waste is very high in organic compounds and that may lead to changes in the body of or the biological oxygen demand of the water bodies. Which means that so much organic material is put into the water body, that it reduces the amount of oxygen that is there in the water body when it gets degraded.

Now, to act upon these organic compounds we can make use of phytoremediation such as root zone treatment. Now in this case the wastewater that is coming from the municipal facility is put into a sedimentation tank, so that a majority gets sedimented and the water that comes out is passed through a bed of wetland plants. And after this water has passed through the root zone of these plants it is then put out into an output.

Now, what happens in this root zone if you look at the root zone there is an oxidized zone and there is an anoxic zone around these roots. Now this reduced zone will be reducing the organic compounds and the oxidized zone will be oxidizing the organic compounds.

Now because of this, oxidation and reduction reactions, what will happen is that a majority of the organic compounds that are there in the wastewater will be acted upon and they will be treated. And once they are treated now the water is safe to be removed and released into the environment otherwise all of these chemicals would have had a toxic impact or a negative impact on the ecology and these methods are pretty efficient.

If you look at the biological oxygen demand reduction you load these plants with the wastewater and they are able to remove the bod. Or if you look at the total suspended solids you load the water and the water that comes out is clean. So, this is acting to purify the water it is clearing off the water, the water becomes transparent and the organic compounds are treated in a manner that it does not cause any further harm to the environment.

That is all for today. Thank you for your attention. Jai Hind!

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Module 5
How can Economics help?
Lecture 1
Need to understand controls

Namaste!

So, far we have looked at why we need conservation, what are the threats to widening. Now, the question is how can we use the knowledge of economics for the aid of conservation? Now in this module, we will look at how economics can help in achieving our objectives of conservation. And this module will have 3 lectures, the first one is the Need to Understand Controls, second is thinking as an economist, and the third is interdependence and gains from trade.

Let us begin with the need to understand the controls. And we begin with a thought experiment. Consider that there is a 747 aircraft and in this aircraft there are two pilots and these two pilots are in disagreement. The question is this plane facing an imminent danger, can this plane go and crash, is there something that is going wrong.

Now, both of these pilots are extremely experienced pilots, but they are looking at different controls and they are looking at these controls correctly. They are reading these controls very correctly. So, both pilots are correctly reading the instrument dials. The pilot 1 is only looking at the altimeter, the on-board radar, and the position of the wing flaps. And the pilot 2 only looks at the fuel gauge, the air speed indicator, and the cabin pressure dial.

Now, the question is it ok to see only certain readings and ignore the rest? Because, if both these pilots do not come to an agreement and they cannot come to an agreement till they talk or they look at each other's readings. Now, if they do not come to an agreement it is possible that both of them will spend their time in disagreement and the plane might go and crash. For instance pilot 2 is looking at the fuel gauge, but pilot 1 is not looking at the fuel gauge.

Pilot 2 looks at the fuel gauge, but pilot 1 does not look at the fuel gauge. For suppose the fuel gauge shows that the amount of fuel in the aircraft is extremely low because of which the plane might not work so, it is possible that this plane that is flying the engines will stop and it will crash. Now, pilot 2 is seeing this gauge and he is currently correctly reading that this plane is an imminent danger of crashing.

But pilot 1 has turned his eyes off this gauge, he says that I am not going to look at this gauge whatever happens. Now, what will happen? This thought experiment tells us that whenever we are working for a common good we need to be on the same page and we need to look at things in a more coherent manner.

Now, similarly when we talk about economies or when we talk about conservation. Why do we do economics? The aim of economics is to maximize the availability of resources to maximize the benefit of resources to mankind and why do we do conservation? We do conservation for precisely the same purpose. Why do we need plants and animals? We need plants and animals for ourselves.

Because, if we do not have these ecosystems that are working properly then, that will lead to a harm to us as a species of homo sapiens as well. When both of us, the economists and the conservationists, are working towards the same goal, it is extremely crucial that both of them read all the dials together.

Now, currently the situation is that the conservationist concentrates upon the loss of habitats, loss of biodiversity, coral bleaching, soil erosion, pollution, global warming, and all these things and the conservationist says that the world is going towards the dome.

Similar to the second pilot: the second pilot says that oh the fuel has gone, this fuel tank has gone empty, we are out of fuel and so, this plane is going to crash. Similarly, the conservationist is looking at all these different aspects, he is looking at the biodiversity and he sees that biodiversity is declining at a very fast pace and so, he says oh the earth is going towards the doom.

But then, we have the economist who concentrates upon increasing GDP, increasing per capita wealth, and resource efficiency. And the economy says oh all over the world the GDP is rising, the per capita GDP is rising, we are using resources with exceedingly greater efficiency. So, there is no cause for concern, because we are doing everything in a much better manner than we were doing previously. Why is there a cause of concern? There is nothing wrong.

Similar to the first pilot who was ignoring the readings of the fuel tank, and was saying that this plane is flying ok. Now, the question is it ok to see only certain readings and ignore the rest? Because if that happens, if we do not take all the readings into account, it is possible that the plane may crash or the earth will doom.

So, we need to get the full picture to make an informed decision. Now, here it is also important to highlight the differences between the economic thought process and the ecological thought process, as we have seen recently. Now, this is something that needs to be changed. Currently, the economists and the ecologists are having a different thought process. They are looking at different dials and they are coming to different conclusions.

We need to bring both of them to the same page but before bringing them to the same page it is important to realize what are the differences between both of these. The first one is the time horizon. The economist looks at a much smaller time horizon than the ecologist. The time horizon in the case of economics is say the next year, the next decade or probably the next century, but not beyond that. Whereas, when the ecologist looks at things he looks at things at an ecological time scale and also at the evolutionary time scale.

The ecologist might say that we should plan for say the next hundreds of years, or probably we should plan for the next millions of years because a number of these processes in ecology they happen at such a slow pace that whatever harm we do to the environment will come to the results or we will face the consequences after a time being.

The ecologist says that whenever we are setting up any new industry, the ecologist would say oh

hang on. First let us see, if we can carry on with this level of pollution, why do not you go and install say a catalytic converter to reduce the amount of smoke that is coming down.

Now, the economist would say oh if I install this machine or if I install this equipment probably I will be able to recuperate the cost in say the next 30 years. So, this is not good from an economic point of view but the ecologist might say that no this is extremely crucial otherwise; we might have a situation of acid rain. Now, this time horizon needs to be kept in mind.

Secondly, the differences between sustainability and utility. Now, sustainable development means a development that meets the needs of the present without compromising the ability of the future generations to meet their own needs. So, when we talk about sustainability we are keeping a long term time horizon.

Sustainability says that we need to meet the requirements of this generation while ensuring that the next generations and the generations after that will also be in a position to meet their own requirements, so we are taking a long time span. Whereas, in the case of utility, utility is a measure of happiness or satisfaction. And this measure of happiness or satisfaction is used for current status, for the current population, we do not calculate utility for the next generation, we calculate the utility for us.

Now, in the case of economics we are more concentrated with the current generation. So, we concentrate on utility. In the case of ecological thought processes, we look at sustainable development. We look at in the case of sustainable development as well. We are emphasizing that we need to meet the requirements of the present generation but then sustainable development says that ok we should meet the requirements of this generation, but we also need to ensure that the next generation is also not harmed, in the longer time span.

This is again another difference between the ecological and the economic thought process at present. Now, the concept of utility has brought us to a thought process that is known as utilitarianism. Now, utilitarianism is "the political philosophy according to which the government should choose policies to maximize the total utility of everyone in the society".

Now, utility as we have seen is the measure of happiness or satisfaction. Now, utilitarianism says that we need to maximize this satisfaction of all the people in the current society. So, it is the political philosophy according to which the government should choose policies to maximize the total utility of everyone in the society.

Now, the important thing to keep in mind in the case of utilitarianism or its definition is that nowhere it says that we need to maximize the utility for the current society as well as of the future generations, it does not say that. Just says that we need to maximize utility, and such a thought process in which we want to maximize the utility of the current society can at times run counter to the thought of sustainability.

This is a major difference between the ecological and the economic thought process. Another difference is whether we are ok with externalities or whether we need to internalize the externalities. Now, externalities are the impacts of one person's actions on the well being of a bystander. "The impact of the actions of one person on the well being of a bystander" and it and there are two kinds of externalities, a negative externality and a positive externality.

Now, negative externality means that the actions of one person create a negative impact on the

well being of the bystander. Then, we call it a negative externality such as exhaust from industries, or exhaust from automobiles. Now, the industrialist who set up the industry is getting all the benefits from the profits that the industry is bringing. But the pollution that is caused by the industry is causing harm to the society as a whole. It could even be at the global level in the case of certain chemicals that are being released.

Now, the negative consequences are faced by everyone in the society, the positive consequences are retained by the industrialists. This is an example of a negative externality because, the industrialist when he or she is taking this decision on whether or not I should set up this industry and what sort of pollution containing measures should I be putting up. Then, he only takes these decisions on the basis of maximizing his or her own utility, maximizing his or her own profits.

And these could even be at the cost of the local surroundings. Because the local surroundings will suffer because of the pollution it is not just the industrialist himself or herself alone who will suffer. So, this is an example of a negative externality. Positive externality is when the action of one person has a positive impact on the well being of others or on the well being of a bystander, good examples are education.

If you educate yourself, if you make yourself a more learned person, then the decisions that you would make in your lifetime are going to help not just yourself, but also your society and also your country and also the world. So, by educating yourself you are not only bringing a positive impact on yourself, but you are also bringing a positive impact on everybody else.

Similarly, if you keep yourself healthy, if you vaccinate yourself, you play a role in stopping the movement of diseases or stopping the spread of diseases. So, vaccination or health or exercising daily these are all actions that have a positive impact on the well being of others, or on the well being of the society or the country as a whole. So, these are positive externalities.

Now, the economic thought process states that we mostly concentrate on the well being of ourselves. Because, economics as we have seen before, economics considers that everybody is a rational person. Now, rationally if I am an industrialist I am setting up an industry and whether or not I should put up equipment to contain pollution is the question before me.

Now, rationally if I do not suffer from the consequences, there is nobody to force me to install this equipment and if I install the equipment my profits will go down, because there is an investment that is involved not only in the installation of the equipment, but also in its running cost. So, rationally I might take the decision that I should not install the pollution containing device because I am taking this decision rationally.

This is the economic thought process. The ecological thought process would say not all the externalities get internalized. In that case, what is the decision that a rational person should make is the correct decision, which means that an ecologist might say that ok, if such and such amount of pollution is released, and it causes so and so amount of health impacts on the surrounding people and if all of those people were to go to a hospital for their treatment.

What is the total cost of that treatment that everybody would have to pay? If you sum that up and if the industrialist were to pay that cost because it is the action of the industrialist that has brought harm to those people. So, the industry should pay for the cost, the polluter pays principle. Now, if that were the situation, then what is the decision that a rational industrialist would

make, is the correct decision.

In other words, what we are saying here is that suppose the cost of installing the pollution controlling device is rupees 10 lakhs and the cost of health care of people in the vicinity, if the device is not installed is say 30 lakhs, and if the industrialist had to pay this cost. So, in that case if the industrialist does not pay the cost of treatment, then he would have to pay rupees 0.

But, if the industrialist has to pay the cost of treatment then, we would have to pay rupees 30 lakhs. Now, if this is the situation before the industrialist and the industrialist has got two options. Option one is that he or she should get the pollution controlling device installed in which case, the cost to the industrialist would be 10 lakh rupees.

The second option is that ok, you do not want to install this pollution containing device, fine go ahead, but any harm that you do to the surroundings you will have to pay for that. That is you will have to pay for the health treatments for all the people in the surroundings that you have harmed because you have not installed this pollution containing device and that cost is 30 lakhs. Now, what would a rational industrialist prefer, would he prefer paying 10 lakhs or would you prefer paying 30 lakhs?

The answer is very simple, he would prefer paying 10 lakh rupees only and he would install this machine or this equipment into this factory. But, this is only possible when the externalities get internalized, when we have a mechanism to force the industrialist to pay the cost of treatment. If we do not have such a mechanism, if we do not have a way of internalizing the externality, the options before the industrialist are very different.

He has the option of not installing the pollution controlling device which is 0 rupees and the cost of installing the pollution controlling device which is 10 lakhs of rupees. If the externalities are not internalized the two options are whether to pay 0 rupees or whether to pay 10 lakhs of rupees. And of course, a rational industrialist would prefer not to pay any amount, he would prefer to pay 0 rupees and he would not install the pollution controlling device.

So, internalizing the externalities is a very powerful concept to help people make the right decisions. Now, the ecological thought process emphasizes that all the externalities need to be internalized before we take a decision on the correct course of action. Here again remember that the decision is a rational decision, but it says that before taking any decision let us first internalize all the externalities.

This is a major thought difference between the ecological thought process and the economic thought process. Now, what are the mechanisms or what are the methods of internalizing these externalities? Now, the first option is a command and control policy, in which case the government has a big role. So, in the command and control policy such as regulation the government would say ok.

No matter what happens, we are only going to permit an industry to be set up, if the industrialist gets this pollution controlling device installed otherwise, there is no permission at all. So, you cannot set up an industry till you agree to install the pollution controlling device.

This is one way of internalizing externality. Or another way of regulation is that if anything goes wrong the polluter will have to pay, the industrialist would have to pay and we will make use of the government machinery, we will make use of the law and order machinery to ensure that if the

surrounding people are harmed then the industrialists would have to pay. That is another way of regulating things.

In a command and control economy or in a command and control government this is one way of ensuring that the externalities get internalized. But not just the government's role we also have certain market based policies, market based policies include things like Pigouvian taxes and subsidies.

Now, in the case of Pigouvian taxes and subsidies, the government says that we are going to impose a tax or we are going to provide a subsidy not because we want to increase our resources through taxation and not because we want to support a particular person through subsidizing, but we are going to use it to ensure or to incentivize people to do something or to refrain from doing something.

Now, in that case it will be called a Pigouvian taxation or a subsidy. Now, how would a Pigouvian taxation or subsidy work in this case? The government might say that ok the cost of installing this pollution controlling device is 10 lakhs of rupees and we are going to subsidize 9 lakhs of it. So, if any person has to install this machine, he or she only has to pay 1 lakh of rupees.

Now, in this way the government is turning the table, the government is saying that you do not have to now make a choice between paying 0 rupees and paying 10 lakhs of rupees, you have only have to make a choice between paying 0 rupees and paying 1 lakh of rupees, and paying 1 lakh it should be an easy matter for an industrialist.

The government might in some cases even bring the subsidies to a level that it becomes 0, or the government might even say that ok, if somebody installs this device we are going to pay that person 11 lakhs. So, in that case the government is paying 1 lakh of rupees to incentivize the person and also covering up all the costs of installing this device. Now, this is an example of a Pigouvian subsidy.

An example of a Pigouvian taxation or would be say if anything go if there is a person who is not installing this pollution controlling device, then there would be a higher level of taxation to ensure that the government has sufficient funds to cover up if there is something, if there is a negative impact to the health of the vicinity.

In that case the government would say, ``Ok you do not have to pay, we are going to take care of all the citizens but to take care of the citizens we also require money, we also require taxation. So, if you do, if you make this choice that you are not going to install this pollution controlling device. So, in that case you will have to pay 5 lakhs of rupees as taxes every year.''

And then the industrialist would think that ok, if I install this machine I only have to pay 10 lakhs of rupees, if I do not install this machine I will have to pay 5 lakhs of rupees every year. And so, in a span of like 2 years, I would have already paid the cost of the machine and from the 3rd year onwards, I will be paying more than 10 lakhs of rupees.

Then the choice becomes much simpler. The industries would say ok, if I can get a tax break by installing this machine let me go for the tax break, let me install this machine. So, Pigouvian taxes and subsidies are also a mechanism through which we can ensure that the externalities get internalized and people take those decisions in which others are not harmed.

Another example is a tradable pollution permit. In the case of tradable pollution permits, the government might say that every industry can release only 100 units of noxious fumes or pollutants. And if any industry releases more than 100 units, then the industry will be completely shut down. Or you have another option, the government might say that in place of say polluting 100 units, you are only polluting say 20 units.

In that case you have 80 units left with you and you can sell these units to some other industry, who is unable to reduce their levels of pollution. So, what we are saying here is that you have an industry that has a quota of 100 units; and if the industry only uses 20 units of quota, then they can sell off 80 units.

Now, who is going to buy these 80 units, there are certain industries for which it is easier to bring down the levels of pollution. Such as our industry in question in which we have a device that is available to reduce the levels of pollution. On the other hand, there could be certain industries that have such processes in which it is very difficult to reduce pollution.

Now, the aim of the government here is to ensure that the total level of pollution is down and it does not cross a threshold. So, in the case of these tradable pollution permits, what would happen is that our industrialist might think that ok, if I install this device I will have to pay 10 lakhs of rupees. But by installing this device, I will be able to save so much on my quota; and I can sell off this quota to my neighbor who is unable to install such a machine and he is going to pay me say 5 lakhs of rupees every year.

And if such a situation arises, then in 2 years I will be able to recuperate the cost of installing this device and from the third year onwards I will be earning a profit on it. Now, in such a scenario the industries would go for installing this device. Now, the benefit to the industrialist in this case is that he or she is able to earn the profit. The benefit to the society is that the level of pollution has been contained and the benefit to the other industry is that it is able to pollute more than 100 units by purchasing this from somewhere else.

So, the total level of pollution is already down, but this has brought in a market mechanism through which one industry can sell off part of its quota to someone else. And a big benefit in such scenarios to the society is that those industries for which it is easier and it is cheaper to reduce the levels of pollution become the first ones to reduce the level of pollution.

So, essentially the society is able to reduce the pollution at a lower cost. So, this is another mechanism that is available to internalize the externalities. Then, we also have certain private solutions; private solutions include things like social norms and mores. Now, in the case of social norms and mores, there could be a social norm in a society that we should not give respect to those people who are polluting the environment.

In that case, the level of pollution is brought down by social action. So, people might boycott those industrialists who are doing a lot of pollution and people might start to honor those industrialists who have taken exemplary steps to reduce the levels of pollution. So, through social norms and mores also we can internalize, we can bring in a mechanism to internalize the externalities.

Other examples are charities to social causes. So, there could be say an NGO, who is able to procure these pollution controlling devices and this NGO goes and fits this device to different

ferent industries say free of cost, but then how does this NGO get money to run this operation, through donations.

Now, in this case the private solution is charity to this NGO. So, the people who are there in the vicinity, they might pay to this NGO as a charity. So, the total level of pollution that they have to tolerate goes down. So, through charities and through NGOs and other social causes as well there is a mechanism to internalize the externalities and bring these negative consequences down.

This is another economic way, in which somebody pays so that the level of pollution goes down. Another private solution is integrating different businesses and this normally occurs in the case of positive externalities. Integrating different businesses it means that, if somebody has an apple orchard and some and this person also starts an apiary to raise honey bees.

Now, in such a scenario what happens is that the person is able to produce honey and sell off the honey and at the same time this person also has the honey bees to pollinate his apple orchard. So, because both of these businesses help each other aid each other. So then, it also makes economic sense to integrate both of these businesses together.

This is also another way, in which internal in which externalities are internalized and especially the positive externalities. Another private solution is through bargaining and contracts such as the Coase theorem. Now in the case of bargaining it is possible that the residents of this area, who are there in the surroundings, might come to the industrialist and they might try to bargain. They might say that ok, you are releasing so much pollutants and that is harming us.

Why do not we come up with an arrangement that can suit you as well as it can suit us because, remember if there is no way in which the residents can force the government to take an action, then the residents might take this action by themselves. So, in this case the industrialist wants to reduce the cost of installing this device and the residents want to save their health.

Essentially the industry does not want to put in 10 lakhs of rupees but if the industrialist does not put in 10 lakhs of rupees, the residents would have to pay 30 lakhs of rupees for their own health. So, the residents might say ok why do not we do this thing, why do not we procure this machine and we install it into your industry.

In that case, the residents are benefited because in place of paying 30 lakhs of rupees, they will only have to pay 10 lakhs of rupees. And the industrialist is also happy because he does not have to pay; or in certain situations and something other than then this can also occur.

It is also possible that the industrialist might say that ok I it is not possible for me to install this device, but why do not I pay you something. So, I will pay you. I will compensate you for the health damages that you have and if the industrialist can come up with a figure that is less than 10 lakhs of rupees, that is also an arrangement between the society and the industrialist.

These are different options that are available for internalization of the externalities. Now, we will look at the Coase theorem in more detail here. So, Coase theorem says that "if private parties can bargain without cost over the allocation of resources, they can solve the problem of externalities on their own".

It only talks about the private party. So, there is hardly any role of the government here. If private parties can bargain without cost, that is it should not cost both these parties to come together in terms of time or in terms of money, that is the transaction costs are reduced. If the private par-

ties can bargain without cost over the allocation of resources, they can solve the problem of externalities on their own.

Now, let us look at one example of this Coase theorem, that we normally see in the case of the tiger reserves. Now, in tiger reserves there are only a set number of vehicles that can get inside on any particular day. Why? Because the national tiger conservation authority looks at this matter and tries to ensure that there is no excessive level of pollution in the tiger reserves.

And at the same time, the animals are not excessively disturbed and so it regulates the number of vehicles that can get inside. Now, there might be some players who have a greater interest in getting inside. A common example is that there are certain Gypsy operators or there are certain guides who are so good at their job, that they receive quite a lot of money in terms of gifts or in terms of honorariums from the people who get inside.

That is what normally happens when this Gypsy driver is taking you to the park. He tells you about all different kinds of birds, he tells you about all the stories that are associated with this park and because of that you are so much entertained that you pay him say 100 rupees extra because he not only took you inside the park, but he also entertained you.

In that case, the benefit that this Gypsy owner will get is much greater than the benefit of some other Gypsy owner who is not good at telling these stories or telling you about the birds and animals. So, in the normal course of operation, one Gypsy owner only gets the amount of money that he or she can charge for taking you inside, but the other Gypsy owner is also getting something extra.

Another difference is that there are some gypsies that are so old, that the cost of running them is higher than say a new Gypsy. So, a person who has a new Gypsy will probably be running at a much greater profit than a person who is having an old Gypsy. Now, if it so happens, that a person who does not get a lot of money from getting inside has been chosen to get inside, because of a roster system and there is another person who thinks that if in place of this person if I were to go I can earn much more.

Now, how can the Coase theorem bring us to a solution that is beneficial to everybody. So, let us look at this, what we are saying here is that there is this Gypsy and if this Gypsy goes inside the profit is 2,000 rupees. If it does not go inside it gets a profit of 0 rupees, because it is not plying inside. And different other Gypsies have different levels of profits, if they go inside.

There are certain gypsies that will earn more than 2,000 rupees and there are certain gypsies that will earn less than 2,000 rupees. So, suppose these are the Gypsies that have been selected as part of the roster system, that is when the NTCA is that 9 gypsies can get inside. So, these are the 9 gypsies that were chosen and this Gypsy was not chosen.

Now, the NTCA is concerned that only 9 gypsies should get inside, the NTCA is not concerned which gypsy should get inside. Now, how can the Coase theorem bring us to a much better solution? Now, suppose this person whose Gypsy was not selected bargains with this person, who if he gets inside will only earn 900 rupees and this person says that ok in place of you getting inside let me go inside and I will pay you.

This person is saying that, I will earn much more profit if I get inside and so in place so it is your turn to get inside, but you give that turn to me. And to compensate you I will pay you some

money, for this jumping right so to speak. Now, how much money will be paid, anything that is between the profit of this Gypsy that is 900 rupees and the profit of this Gypsy that is 2000 rupees.

Let us say that both of these bargain and they agree on 1200 rupees 1200 rupees and so, this Gypsy owner says that ok you pay me 1200 rupees and I will keep my Gypsy outside and you can go in my place. Now, what happens? This person who would have earned 900 rupees, has now earned 1200 rupees and so this person is happy because, in place of earning 900 he is earning 1200. What about this person? Now, if this person did not get inside because, it was not selected in today's roster.

So, he would have earned 0 rupees. But, now that he has earned this, he has paid for these jumping rights and he now has the chance to get inside he will be earning 2000 rupees, now out of these 2000 rupees he will be paying 1200 rupees to do this Gypsy owner. And now, he will be left with 800 rupees.

So, for this Gypsy owner the choice was either 0 rupees or 800 rupees and this Gypsy owner is now earning 800 rupees, so he is also happy. So, this Gypsy owner is happy because he earned 300 rupees more. This Gypsy owner is happy because he earned 800 rupees more. And NTCA, of course is happy because only 9 gypsies got inside and there is no other issue with this.

So, by bargaining themselves, by doing this bargain both of these parties have come up with a solution that is beneficial to both of them. So, this is an example of the Coase theorem and we normally apply the Coase theorem in the case of conservation these days. For example, through payment of ecosystem services and a good example of this is the Catskill watershed.

What is this story? In New York, the water that is supplied comes from these mountains that are known as Catskill Mountains. Now, the city of New York has got two options, option one is which is the default option that most of us use is that whatever water comes to the city has to be treated. So, you set up a water treatment facility and you run this facility and you pay for its installation you pay for its running, and this is the amount of money that you will have to spend to get good quality water.

The second option, that these people thought was that why do not we do something so that the water that comes to the city does not have to be treated at all. So, they started looking at what causes pollution in this water? And they saw that the people in the Catskill Mountains were also doing agriculture and when these people do agriculture they will be using fertilizers, they will be using pesticides, and these chemicals are coming into the water.

So, the people of New York said ok why do not we do one thing, if we set up our water treatment facility and say we have to pay say 1 million dollars. In place of doing or spending this 1 million every year, if we pay say 500000 dollars to the people who live on top there on the Catskill Mountains and we will say we will tell them that, that you guys refrain from using the fertilizers, you guys refrain from using the pesticides.

And of course, if the fertilizers and pesticides are not used then your crop yields will go down and we are going to compensate you for that. So, we are paying you these 500000 dollars, to compensate you for the lower productivity. Now, the farmers might think that ok, if I do not use fertilizers and pesticides my crop yields surely go down, but what is the extent to which they go

down? It is not that we will be able to produce no crops.

We will be able to produce crops, but probably of a lesser quantity. So, if they calculate and they come to this conclusion that ok, if we go for organic agriculture, we will only be earning 300000 dollars in place of say 400000 dollars that we are earning every year. So, there is a loss of 100000 dollars every year, but now these guys are paying us 500000 dollars to go for organic cultivation.

So, what is the harm? In this way the farmers who are out there in the Catskill Mountains are able to earn much more than what they would have earned through traditional agriculture, so they are benefited. And the people of New York they would in place of failing out say 1 million dollars every year, they can make go with 500000 dollars. So, there is a cost cutting, there is a saving for the people of New York as well.

Now, this is an example of the Coase theorem in which there are two parties that are bargaining at their own private levels and they are coming up with a solution that is beneficial to both of them. The farmers are happy, the people of New York are happy. And of course, the water quality because it is now so good that it can be directly used for drinking.

So, it also helps the environment because you do not have to pay a cost of installation, you do not have to release greenhouse gases because you would have required electricity to run your plants. So, it helps the environment as well. It also helps the biodiversity because those fertilizers and pesticides that were polluting the waters are now not there and so the biodiversity also is much better.

Another difference between the economic and the ecological thought process is the kinds of goods that we are concerned with. And we can divide goods and services into four different categories, based on two concepts: whether they are excludable and whether they are rivals in consumption. Now, what does this mean? Excludability means that "the property of a good whereby a person can be prevented from using it".

Now, what does that mean? It means that if I have this pen, I can say that this is my pen and I will not allow you to use this pen. In that case this pen is an item that is an excludable item. So, I can exclude others from using this pen. Rivalry in consumption means "the property of a good whereby one person's use diminishes another person's use".

It means that, if there is a tree and this tree is all full of mangoes and if I go there and if I take these mangoes and if I eat these mangoes there are less mangoes that are available for you to take out. So, your consumption and my consumption are rivals of each other. The more I consume the less you consume, the more you consume the less I consume so, this is known as rivalry in consumption.

Now, on the basis of excludability and rivalry in consumption, we have four different kinds of goods. There are certain goods that are both excludable and rivals in consumption which are known as private goods such as clothing. Now, clothing is excludable because, I can always say that this is my cloth and I will not permit you to use it.

At the same time it is a rival in consumption because, if I purchase one piece of cloth from a shop, then it is not available for you to purchase. So, there is a rivalry in consumption, either I can have this plot or you can have this plot. When there are other goods that are excludable, but

they are not rivals in consumption, such as fire protection.

In the case of fire protection we can say that we are only going to provide fire protection to these people who are paying for it. So, we can always say that if there is a society that pays for fire protection we will provide them with fire services. If a society does not pay for it we will not provide it with fire services. But this is not a rival in consumption, because if you pay for this for fire services and you are able to get the fire services it does not mean that I will not get the fire services.

It is not a rival in consumption. So, these goods are known as club goods. Then there are certain other goods that are rival in consumption but they are non excludable such as the environment. Now, why are these non excludable because a thing such as the air now, if I am breathing air I cannot prevent you from breathing the air. It is non excludable, but it is a rival in consumption because if I add pollutants to my air, then because it is a non excludable thing and the air is there everywhere.

These pollutants will also reach you. The more I harm this resource or the more I consume this resource the less is available for you. So, this is a non excludable, but rival in consumption so, this is a common resource. And the fourth kind of good is known as a public good, such as the national defense.

It is neither excludable nor a rival in consumption, because if my country is protected, your country is also protected. So, it is non excludable and if I protect my country it is not that your country is not protected. So, it is not a rival in consumption. Now, the difference between the economic thought process and ecological thought process is that a lot of ecological thought processes occur around the common resources of the environment.

Whereas, the majority of economic thought processes occur around private goods. So, there is this major difference between the thinking of economists who are more concerned about private goods and the thinking of the ecologists who are more concerned about the common resources.

Now, we will look at an example to see that it is not that both of these thought processes are very different. We can bring the economist and the ecologists on the same page, we can bring them to a common solution that can benefit both of them and this example is one of the linear infrastructure. Now, linear infrastructure refers to those basic physical and organizational structures and facilities that are needed for the operation of a society or enterprise.

This much portion is the definition of an infrastructure, those basic physical and organizational structures and facilities that are needed for the operation of a society or an enterprise. But, linear infrastructure means that they can be represented as straight or curved lines. And examples are roads, railways, power lines, canals, pipelines and so on. So, a road is an infrastructure that you can represent either as a straight line between two points or as a curved line between two points. So, this is a linear infrastructure. So, good examples are roads, railways, pipelines, and so on. Now, it is known that linear infrastructure through the wildlife areas leads to conflicts. So, this is something that the ecologist wants to avoid. The ecology says that if you build a road in the forest area it harms the biodiversity. How does it harm biodiversity? Because animals use roads, we normally see animals on all different kinds of roads.

And if there are vehicles that are flying, then there are also accidents and animals die on getting

collided with different vehicles. So, roads are a method of killing. Roads also cause pollution in terms of air pollution, sound pollution, and light pollution. So, if there is a road then you are also harming the forest, you are harming the biodiversity. You are providing a means through which people can throw waste products into the forest, which is another harm.

Roads are barriers to wildlife movement because this wildlife area is very different from this paved structure of the road. And so, a number of times the animals who want to move from this side to this side will avoid going on top of the road. They act as barriers, they act as physical barriers, they act as psychological barriers.

And a lot of this has also got to do with the amount of or the number of vehicles that are plying per unit time. If you have a very small number of vehicles, then probably the animals are able to cross the road. If you have a very large number of vehicles then probably the animals see a wall of vehicles that is plying through these roads and they just do not cross.

But, in these central areas where the vehicle density is in between, the animal sees that ok vehicles are coming but they are not coming at such a huge density that I might be unable to cross. So, the animal thinks ok let me take a chance and cross this road, and as it tries to cross there is a vehicle that comes and hits this animal and the animal dies. So, in this middle region we have the highest number of deaths as shown in this rate curve.

And when we look at this barrier effect it also depends on a number of other factors such as traffic intensity if there is more traffic intensity there will be a wall of vehicles, the speed of vehicles, the sensitivity of the drivers whether they are using headlights or horns and so on, the presence and location of animal crossings.

If there is a road with a very heavy traffic, but then there is also a bridge and the animal can cross under the bridge so; in that case it is not very big of a barrier. Movement patterns of this species so, especially in the rainy seasons when a number of species are on the move, the barrier effect is much more pronounced.

Species specific preference of road use, there are some species that are more comfortable in using a road, there are some species that completely avoid the road. The edge features, what is the height of the embankment? If the embankment is too high the animals will be unable to get to the road.

So, that will be a very great barrier. Time of the day, time of the year and species diversity in the surroundings. Another harm, with these linear infrastructures like roads is that roads fragment the habitats. So, here you have one habitat: you were having a big habitat and now it has fragmented it into these three sections.

There was this beautiful forest but now the animals cannot cross from this side to this side. So, it has created a fragmentation. Construction of roads causes loss and destruction of habitat because to construct roads or railway lines you will have to cut off trees.

You will have to perform earth work. So, even during construction it creates a problem for biodiversity. It can lead so, this is an example of earthwork in which a big sized hole has been dug, construction causes loss and destruction of habitat. Roads also facilitate the destruction of habitat. Why? Because roads permit accessibility to different areas. So, if people can reach an area they can also come there and cut trees, they can also poach animals.

Roads also facilitate the destruction of habitat. Roads also increase interaction with humans. So, this is an example in which a Nilgai hit a vehicle, the Nilgai died on the spot but both the people that were traveling in the vehicle, were also critically injured. Roads change animal behavior. Langurs normally do not interact with humans, but because people have been feeding these Langurs, now it has changed their behavior. They always come up to beg for food. This is another example, these people are feeding these animals, they are feeding the monkeys, they are feeding the langurs, they are feeding the wild pig, they are feeding the peacock, and this is not a behavior that would be seen in an actual environment.

Normally, if you step out of your vehicle all the animals will just run away they are so afraid of humans. But in this case, the behavior has completely changed. In a number of situations there are also incidents in which the animals attack the vehicles. This is also an issue for people because one option that the ecologist might suggest is that we should reduce the speed limit.

So, if the vehicles are plying at a lower speed then there is a chance that the animals will be saved because the animals will have much greater time to cross and avoid the vehicle, avoiding the collision. But then, if we try to reduce the speed of the road then that is also having an impact on development because we normally want to go from point a to point b as soon as possible and this will hamper that.

Linear infrastructures lead to a number of human wildlife conflict situations. A human wildlife conflict occurs when the wildlife requirements encroach on those of human populations, with costs to both the residents and the wild animals. Examples include things like crop depredation, spreading of diseases, predation of humans and livestock, road accidents, poaching, habitat degradation, loss, road kills and so on.

So, what is the option that is left with us? The option to avoid these conflict situations is to keep humans and wildlife separate from each other. The option is education and awareness, the option is mitigation measures, underpasses, overpasses, canopy bridges, culverts and so on. Now, what do we mean by these mitigation measures?

Remember we said a short while back that if there is a road and this road is acting as a big barrier but there is also a bridge. So, the animals may use the bridge to cross and in that case the interaction between the animals and the humans goes down. So, the animal is saved because it avoids a collision, the humans are saved because there is no vehicle, there is no animal to harm their vehicles and they can also move at a much faster speed.

This is a mitigation option that is available, but the question is how do we ensure the implementation of this mitigation option and do we need to have this mitigation option at all places? Even for smaller animals, the answer is yes, the ecologists would say yes. These smaller animals play a very big role as scavengers and if these animals were not there then, we will have a very big problem of dead animals that are not being disposed of.

Now, either the economist and the ecologist might go on disputing these facts or the other option is to bring them both to the same page and to make the economist realize that these mitigation measures not only protect the animals, but they also increase surplus. They enhance the surplus of the society. Why? Because they lead, they reduce the chances of human deaths and accidents. Vehicles ply at higher speeds which leads to economic prosperity. It also aids in the conservation

of biodiversity which has its own benefits for enhancing the surplus of the society. Now, the point to emphasize here is that the mitigation measure is not just a tool of conservation, it is also a tool of good economics, and this is why it is important to understand economics.

So that you can make the economist understand things in his or her language. So, if you were to portray a bridge or a mitigation measure as a way of protecting wild animals, then probably the economist might not agree. But if you portray a bridge or a mitigation measure as a means of enhancing surplus by protecting the lives of human beings, by protecting the property of human beings, by ensuring that they are able to move at faster speeds, and by giving them the benefits of biodiversity, then probably it will be a very different matter.

The economists may completely agree with your point of view. Now, similarly it is important for the ecologist also to understand that we cannot go on saying that ok this thing is important for animals so, this has to be done. Because, that is not a persuasive argument. You also have to know about economics so that you can make use of the language of economics, you can make use of the thought process of economics to portray your case in a much better manner.

So, the implementation of these tools such as the mitigation measures can be ensured through an understanding of economic decision making and incorporation of a thorough economic analysis, not just a superficial one. So, in other words we can say that economics is a good tool for good conservation. If you did not have economics you would not be able to perform conservation because nobody is going to listen to you.

And at the same time conservation is a tool for good economics, because by using the tools of conservation we are able to enhance the total surplus of the society. Now, it is important to remember here that both the economist and the ecologist are working for the same goal of enhancing the total surplus of the society, but both of us need to understand each other's controls, each other's devices.

So that we do not fall prey to the situation in which there are 2 pilots and they are not understanding each other's controls, they are looking at completely different readings. And it is important to remember here, that the solution to the issues that have been generated by "Economic" decisions.

In certain circles, it is very fashionable to say that all the harm to the environment has been done due to economic decisions that were made. Whether we talk about pollution, whether we talk about global warming, whether we talk about loss of biodiversity, there are certain ecologists who always put the blame on the economist and say that it is because of the economist that all these harms have come to Mother Nature.

But it is important for them to realize that the solution to these issues that were generated by "Economic" decisions is more Economics, and not less. It is their duty to ensure that the economists also get the point of view that these tools of conservation are also the tools of better economics and of enhancing the surface of the society.

That is all for today. Thank you for your attention. Good day. Jai Hind!

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Module 5
How can Economics help?
Lecture 2
Thinking as an Economist

Namaste!

In the last lecture we saw that conservation and economics are both related to each other, both are being done for the common aim of providing more and more benefits to more and more number of people, but still in certain cases, there are difficulties, because there are some people who might consider that economics and conservation are at loggerheads. They are not serving the same process.

The solution lies in having more and more economics. The people who are there in a position of decision making, they need to be made aware that if we are doing good conservation this is also going to be bringing benefits to a large number of people. And a good example is the provisioning of mitigation structures such as underpasses for the movement of wild animals.

Now, underpasses not only provide a way for wild animals to move across a road, but they also provide protection to people, because they will not find a wild animal out there in the road, to collide with their vehicles, to destroy the vehicle and probably also lead to the death of a some human beings in these accidents.

If we do not have underpasses the other option for people to move safely is to lower their speeds. So, in a number of areas we find that there is a speed limit regulation of say around 20 kilometers per hour, but then if we go with a speed of 20 kilometers per hour that also leads to certain detriments to a large number of people. Because goods will move slowly, people will move slowly and so in such a situation doing development of the area will be more difficult.

The issue here is to bring the economists and the ecologist on the same field and come up with certain solutions through which we can find a means to satisfy both the circumstances. It is important to know the language of both these people, it is important to know the language of economists and the language of the ecologists. And in this lecture, we will have a look at the language of the economist; we will have a look at how an economist thinks and how he or she takes a decision.

In particular to use economics we must know economics and in this lecture we will look at certain terms; terms of economics or let us say the lingo of the speed. We also have a look at the methods that are employed. Now, different disciplines might be using different methods. Now there are some methods that are specific to a field; however, there are certain methods that are

common across all fields such as the scientific method. We will have a look at what kinds of methods are used in economics.

We will also try to discern what kinds of analysis are done in this field. And then we will also look at the field realities.

Let us begin with the terms. There are a number of terms in economics and to understand any field it is important that we know the language of the field. For instance when an economist says that the market is going up or the market is going down or the market is essential for such and such society or the market says. What does this market refer to? Is it referring to your local market, is it referring to the stock market, is it referring to something else.

To understand the language of an economist it is important to know the terms that an economist uses. So, for instance a market is defined as a group of buyers and sellers of a particular good of or service. It is a group of buyers and sellers which means that you cannot have a market with say just a few buyers or just a few sellers or say just one buyer and one seller that will not make a market. You require a large number of buyers and a large number of sellers.

And these are buyers and sellers of a particular good or service. Which means that we can have different kinds of markets, we can have a market for goods, we can have a market for services. In the case of a market for goods we can have a market for say a good, we can have a market for land we can have a market for construction activities. In the case of services we can have a market of education.

Now, in any of these markets there are certain people who want to procure these goods and services and these people are known as the buyers and there are certain other people who provide these goods and services to the buyers and these people who provide these goods and services are known as the sellers. Now, in any market you will have a group of buyers and a group of sellers for that particular good or service.

Then we have quantity demanded; quantity demanded of any good or service is the amount of goods that the buyers are willing and able to purchase. Quantity demanded is the amount of goods that buyers are willing to buy. So, they must be willing and they must be able to purchase, which means that when we look at quantity demanded if there is a section of buyers that says ok I am going to procure this item for say 2 lakhs of rupees, I am willing to do that, but then those buyers do not have the funds with them.

They are not able to provide this much amount of money. So, in that case we will not include that section into the computation of the quantity demanded or there might be certain people who have money with them, but they do not want to spend it on that particular good or service, and in that case as well we will not include it in the definition of quantity demanded.

The quantity demanded is the amount of goods that buyers are willing and able to purchase. Now it is very important in the case of conservation, because there is a market for a lot of goods that are to the detriment of nature and ecology. So, for instance there is a market for tiger skin. Now why is there a market for tiger skin? Because there are certain buyers who want to procure tiger skin, there are certain sellers who want to sell tiger skin.

Now, where will these sellers get the tiger skin from; of course, they will go into a forest and they will poach a tiger. Now, if there is this market and you want to curtail this market, you want

to stop this market, so it is important to know how these people are providing these goods and services, where this market is and what is the quantity that is being demanded by this market. Because to stop this market you will have to act at different levels, you will have to act at the level of the buyers.

If somebody is trying to buy these tiger skins you would have to stop them. You have to act at the level of the sellers and then you also have to act at the level of the market. Now, remember that a market is a group of buyers and sellers of a particular good or service and these days the online marketplace has also come up as a very important market.

Now, when we look at the online marketplace, at times you will find that even on the most reputed online marketplaces there might be certain people who are selling products such as a claw of a tiger or say the skin of the snake and so if you want to perform conservation you will have to act at the level of these markets as well.

So, it is important to know what is the market, who is the buyer, who is the seller, what is the quantity demanded, what is the quantity supplied and then you can even act at this level. How do you reduce the willingness of the buyer? How do you reduce the ability of the buyer to purchase a thing such as a tiger skin?

Willingness of the buyer can be reduced by say coming up with certain means of education or awareness or by say putting up a social cost, or of putting up certain excessive taxation or excessive punishment if anybody comes to know that that such and such person has bought a tiger skin or you could even act at the level of ability.

If you know who are the buyers who preferentially try to buy a tiger skin you might try to reduce their ability to purchase a tiger skin. Now, this reduction of the ability can be through say more taxation of those people or say by freezing up of their accounts.

Now, if you freeze the account of a potential buyer. In that case this buyer is no longer able to procure the goods and so the amount of quantity demanded in the market will go down. And as the quantity demanded goes down the price will go down and it will no longer be profitable for the seller to go and poach a tiger and bring it to the market.

It is important to know what the quantity demanded is. Similarly, you need to know the quantity that is supplied, the amount of a good that sellers are willing and able to sell. So, the sellers must be willing and they must be able. Here again there could be certain sellers that are willing to sell a good such as tiger skin, but they are unable to sell it, because they do not have access to the resources, or there could be certain sellers who have the ability to hunt a tiger, but they are not willing.

And in a number of cases we find that there are people who live around a tiger reserve. So, these people have access to the tiger, but tiger conservation has been successful only because these people are unwilling to go into the forest and poach a tiger. So, we also have to work at the level of the willingness and ability of the sellers or the potential sellers. So, these are some important terms in economics.

Another term is elasticity; elasticity is a measure of the responsiveness of quantity demanded or supplied to a change in one of its determinants. Essentially if you look at say a thing such as a price elasticity of demand, it is percentage change in the quantity demanded divided by percent-

age change in the price. Essentially if there is a change in one or more of the determinants of a good then is the quantity demanded or quantity supplied does it change or not?

Now, if there is a good for which when there is a change in its determinants and the amount of quality or the or the or the quantity of goods that are supplied or the the goods that are bought, if it changes then we will say that the demand or the supply curve is elastic.

Whereas, in certain other cases if the demand or this if the quantity demanded or the quantity supplied if it remains the same then we will say that the demand or supply for such and such good or service is inelastic.

Now, it has been seen that in the case of certain goods; such as food grains, the demand and supply are very inelastic and why are they inelastic? Because even if a person has access to more funds or if the person shifts to some other place, there is a limit to how much food grains he or she can eat. And so the quantity that has been demanded is more or less fixed.

Similarly in the case of a number of industrial products, it is difficult to change the quantity that is applied on a short term basis, and so the supply of such goods and services will be called inelastic. There are also other terms such as comparative advantage externality and so on and will explore all these different terms as we move through the course.

Next let us have a look at the methods of economics. And the most important method that we make use of is the scientific method. Now, the scientific method works like this: there is an observation and any observation can lead to a question. So, for instance there is an observation that there is a market for tiger body parts. The question is, ok what are the determinants of this market?

Does this market depend on who is the buyer or who is the seller? Or does this market depend on what the currency exchange rate is? Or does this market depend on what is the level of insurgency in areas where you have the tigers? So, that it is easy to post the tigers.

There could be a number of questions that can be asked based on any observation. Now, based on any of these questions we can come up with certain hypotheses. Now, a hypothesis is a possible explanation for what is going on. Now this possible explanation could be correct or it could be incorrect, but so it be the hypothesis has to be formed.

For instance we can say we can formulate a hypothesis that there is this market for say food grains and the market for food and the amount of food grains that is supplied to this market depends on say the cost of fertilizers.

Now, it is possible to say that in this area fertilizers are very expensive as compared to the other raw materials that are needed to manufacture food grains. And so if the price of fertilizers goes up then people will be unable to procure more and more fertilizers and so the amount of fertilizers that are applied to the crops will go down and so the quantity that is supplied will go down.

But there could also be a situation that the fertilizers are very cheap as compared to say the cost of irrigation. And so there is hardly any impact of the cost of or of the price of fertilizers on the quantity of food grains that is supplied in this market. Now, whether a hypothesis is true or not it will have to be discerned, but before we get to the task of discerning why a thing is happening in a certain manner, we will first have to formulate a hypothesis.

We can formulate n number of hypotheses. We can say that the quantity of food gains that is

supplied to this market depends on the price of fertilizers or it depends on say the price of irrigation, or it depends on the price of transportation, there could be n number of hypotheses.

And then we will try to look at each and every one of these hypotheses in more detail. Now how do we look at or how do we discern a hypothesis? It is done either through experiments or through observations. Now what can be an experiment? So, suppose we wanted to see if the price of fertilizers is the most important factor that determines how much is the amount of food grains that is supplied by a seller.

In that case we can artificially pick certain farmers and we can provide them with fertilizers at a reduced rate. So, we can provide them with certain subsidies. We can tell them that ok if you purchase 1 kg of fertilizers, we are going to pay you 20 percent of the money, you will only have to pay 80 percent of the sum.

In place of a higher price now the farmer is paying a lower price and then we can formulate certain groups we can say that there is this cohort that is paying a 100 percent price, there is the second cohort that is paying 90 percent price, there is the third cohort that is paying 80 percent price and so on.

And then we can try to look at what is the amount of food grains that is supplied by these different cohorts into the market, so this can be an experiment. Or in certain cases when it is difficult to perform an experiment, we can even look at more observations.

For instance we can say that ok if everything else remains same, but then also the price of fertilizers would be varying to some extent, or probably there are different places in our area of study and in one place the price of fertilizers is more in another place the price of fertilizers is less and everything else is more or less the same.

In that case the scientist or the economist might try to figure out if these natural variations in the prices have got something to do with the quantity of food grains that these different sellers provide to the market. So, we can explore a hypothesis either through experiments or through observations.

And when we do these experiments and observations it is possible that the hypothesis gets rejected. So, it is possible that we formulated all these different cohorts, we gave them different amounts of subsidies, but still every cohort provides the same amount of food grains or supplies the same amount of food grains to the market.

In that case we will reject the hypothesis that the price of fertilizers has the majority share in determining the amount of food grains that are supplied by the seller to the market.

This is a hypothesis that gets rejected through either the experiments or through the observations. And when this happens then we will go ahead with the next hypothesis or we will even formulate a new hypothesis. So, in this case we might say that the price of fertilizers has nothing to do with the quantity of food grains that these people are supplying, so probably it is the price of transportation. So, that is the new hypothesis that the price of transportation governs the quantity of food grains that are supplied by the sellers to the market. This is the next hypothesis.

And what do we do with this hypothesis? We repeat the process, we go ahead with more experiments and observations. And we perform these two operations of formulating hypotheses and checking them out through experiments or observations till we have reached a point where the

hypothesis gets confirmed.

Suppose our hypothesis that the cost of transportation determines the quantity of food grain that is supplied to the market. Suppose we are able to prove this hypothesis in our study area, so in that case we will formulate a theory.

Now, this theory would say that the cost of or the price of it of transportation determines the amount of food grains that is supplied to the market, but then it is also possible that this theory is only applicable to the current area of study. It is not applicable everywhere else. In that case it will remain at the level of a theory, but then if a theory stands the test of time.

So, we test it in different locations, we test it in different periods of time, we test it under different circumstances and every time we find that it is actually the price of transportation that determines the quantity of food grains that are supplied by the sellers to the market. If that happens then we will upgrade the theory to the level of a law and then we will call it the law of say governance of the quantity of food grains supplied to the market.

Another example from a very different field is that suppose you have a torch and this process is not working, how do you apply the scientific method?

Now, remember that the scientific method's aim is to help you get to the correct conclusion. So, your torch is not working and there could be n number of things that are wrong with the torch. Probably the batteries have died out, probably the bulb has got fused, probably the switch is not working, probably the wires are broken, there could be a number of things. Now, we can apply scientific methods to any observation and to any question.

In this case the observation is that the part was not working, the question is why is the torch not working? So, we will formulate certain hypotheses, the first hypothesis is perhaps the battery is dead. Now, how do you check whether this is the correct hypothesis?

Will you change the battery or you charge the battery and check if the torch works. Now if the torch still does not work then our hypothesis that the battery is dead is wrong, because if this hypothesis was correct the torch should have worked when you change the battery or when you charge the battery.

So we reject this hypothesis that the torch is not working, because the battery is dead. Then we come up with another hypothesis that the torch is not working, because the bulb has been fused. So, we change the bulb. So, this is the experiment, you change the bulb and check if the torch works.

And you find through this experiment that the torch still does not work which means that the bulb was not fused, because you have changed the bulb in that case. So, one by one we are formulating a hypothesis, we are testing the hypothesis and we are accepting or rejecting the hypothesis.

If the bulb is not fused then perhaps the switch is not working. So, in that case the experiment is you change the switch and then check if the torch is working. And now through this experiment you come to know that the torch is working. In that case you can through this method of testing out different assumptions, different hypotheses, one by one you can reach a conclusion about why while you were observing the observation that you were observing.

That is through looking at all of these hypotheses one by one you can come to the conclusion that

your torch was not working because its switch was malfunctioning, which you could not have done if you looked at all of these different aspects at the same time.

So if you have a torch that is not working and you wanted to check the bulb, you wanted to check the battery, you wanted to check the switch, you wanted to check the wires, everything at the same point of time then it would have been very difficult to come to the conclusion or especially the right conclusion about why your torch is not working. Now, similarly in the field of economics there are a number of questions, there are a number of observations and the economist uses the scientific method to understand or to explain why a certain thing is behaving in the way it is doing.

We have observations about things such as inflation. Why does inflation occur? Why do we have unemployment in our society? And all of these questions are understood through the scientific method.

And if any of these theories stands the test of time then we say that we have come up with a law. So, if you want to understand how an economist thinks, it is important to know the scientific principle and to deploy scientific principles in different circumstances.

Now in the case of economics the experiments are in a number of cases a natural experiment. Now, natural experiment means that, especially because economics has got a lot to do with different people. So, you cannot, say, subjugate a person to malnutrition or you cannot subjugate a person to poverty, just to test if a certain observation is because of a certain hypothesis, because there are human costs involved.

If you wanted to check if the price of crude oil has got something to do with, say an observation x , you cannot just go ahead and increase the price of crude oil. Because one; in a number of cases, you will not have access to the power to increase the price of crude oil and two because of the human costs that are involved. So, the economist in a number of cases makes use of natural experiments.

What is a natural experiment? Out there in nature even without us doing anything there are variations. So, suppose somebody wants to understand the role of poverty he or she can look at two different areas; one in which more and more people are poor and the other area where people are less poor. Or if somebody wanted to understand the impact of an increase in the price of crude oil then they only have to look at those periods of time such as wars, where the price of crude oil goes up.

So, these natural experiments can be made use of in understanding and checking any hypothesis. And in the scientific method we also make use of assumptions and models why? Because if you look at the scientific method you will find that there are a number of hypotheses that need to be tested and if we do not make certain assumptions then there will be so many hypotheses that it will be very difficult to check any of those.

So, for instance if you wanted to check if poverty has got something to do with the amount of education that people receive. So, and when you are doing any experiment or when you are looking at a natural experiment then it is possible that not only are these people poor, but probably they are also living in say a nation with a very different political principle. So, we are looking at one society that is living in a capitalist country and another society that is living in a communist

country.

Now, if a number of things are different between both of these societies then we cannot pinpoint whether the amount of education that people are receiving is because of poverty or not. So, we will have to make the assumption that everything else being constant poverty has so and so impact on education, and so this is an assumption that we need to make use of.

Similarly, we also make use of a number of models. Now, what is a model? A model is a simplified depiction of reality. So, for instance if you look at say the climate of India, then a model would say that ok in the months of May or June you have the summer season, in the months of December and January you have the winter season, but the reality could be different, the reality would be that in case of December and January being winter months you could be having a winter from say 15th of November or a winter that extends till the end of February in certain years.

But then if we want to discern the rule of something we will have to simplify things. If it is very much complicated then and then looking at or making pinpointed conclusions would become more difficult. And so we make use of models which are simplified versions of reality.

A model can be defined as a simplified description, especially a mathematical one of a system or a process, to assist calculations and predictions.

Io, it is a simplified description. So, you are removing most of the complexity, especially a mathematical one. Now why do we prefer mathematical models? Because a mathematical model makes it much easier to predict things, it has a better predictive power. So, a model is a simplified description, especially a mathematical one of a system or a process. And why do we make a model? To assist calculations and predictions. It makes calculations easy and it gives us a certain amount of predictive power.

Why do we use models? Models are simple to understand by removing the specifics. So, in the case of the climatic model you are removing the specifics about which date or say on which date what was the temperature. We are just looking at a very simplified depiction when we say that so and so months are summer months, so and so months are winter months and then spring and autumn and so on.

So they make things simple to understand by removing the specifics. They help us concentrate on the most relevant variables. So, for instance if we wanted to check whether a particular activity is more in the summer season and less in the winter season. So, if we made use of this model, we do not have to concern ourselves with what was the exact temperature on that day, what was the exact humidity on that day.

Now, remember that all these different factors could also have a bearing on our observation. But then by removing all of these variables, we are making it simple to understand and we are concentrating on the most relevant variables. It promotes reflection and clarification of ideas, it gives a certain amount of explanatory power.

Through a model we can explain things and we can even predict what is going to happen in the future. If we have a simplified model it is easy to understand things, it is easy to explain things to others and it is also easy to predict what is going to happen in the near future.

But then when we are simplifying things, we are also removing a lot of details. So, this is a limitation of models. Most of the models are approximations; they are not exactly how the real-world

functions. And remember that this is ok because we made a model, knowing that we are unable to comprehend the complete reality and model will help us understand the reality, and so there will be certain limitations. Then there is a tradeoff between accuracy and predictive power and simplicity.

Now, if you have a model and you want to be extremely accurate then you will have to consider all the smaller variables that were also playing a part, but then if you include all the smaller variables then your model becomes so complicated that it becomes difficult to comprehend and difficult to explain and probably even difficult to deploy. So, there is always a tradeoff, between accuracy and predictive power on one hand and simplicity. With more predictive power complexity goes up which might defeat the purpose of the model.

Let us now have a look at certain models that we commonly use in economics. The first one is the circular flow diagram. It is a visual model of the economy that shows how money flows through markets among households and firms. So, a circular flow diagram is a visual model. It is a model and it helps you to visualize things. It is a model of the economy and it shows how money flows through markets among households and firms.

What does this model say? This model says that there are two big entities; there are firms and there are households. Firms are those entities that produce and sell goods and services. So, they are the producers and they are the sellers of goods and services. Now, to produce these goods and services they hire and make use of factors of production. So, you can understand a firm easily by visualizing say an industry.

Now, an industry is manufacturing certain goods or it is providing certain services, and to manufacture these goods and services it requires labour. So, how will it get labour, it will hire labour, it will employ people. A firm is the set of entities that produce goods, that produce and sell goods and services and for production, they hire and use the factors of production. Factors of production means they are using land, labour and capital.

The other big entity is the households. Households are those entities that buy and consume goods and services. So, these are the buyers of goods and services. They own and sell the factors of production. So, the households own their own labour and they sell their labour to the firms to help them produce things and in return they will be getting a salary or the households are those entities that own the land and they will make this land available to the firms in exchange for say a rent.

Households buy and consume goods and services, they own and sell the factors of production. So, there are these two entities. Now these two entities interact in the market, and remember that a market is the place where buyers and sellers are coming together, but markets are places where buyers and sellers of a particular good or service come together. So, in this case we can clarify that there are two different markets; there are markets for the goods and services.

Now, goods and services are those things that the firms are producing and the firms are selling. On the other hand the households buy these goods and services. So, in the market for goods and services, the goods and services are sold by the firm in this market and they are bought by the households. Now, when the households are buying the goods and services from this market, they will have to make a spending, they will have to pay something.

So, let us say that they are paying in rupees. So, one rupee is moving from this household to the market, because a certain portion of goods and services are being bought by the households in this market. And this market is then channelizing this rupee to the firm and the firm is getting this money in the form of revenue. So, this is the revenue of the firm. And why is the firm getting this revenue? Because it is selling goods and services. So, this is one market in which the firms and the households interact with each other.

Now, if you do not have any other market, if we have only one market, then there will be a situation where the households will very soon end up all the money that they have, all the money will get accumulated here and the households will only have certain goods and services that they have bought from the firms. So, after a while this economy will stop. Now the reason why the economies do not stop is that we have another market which is known as the market for the factors of production.

Now, in the market for the factors of production the firms buy and the households sell. Now what do the firms buy? The factors of production. So, the firms are buying the labour of people who reside in the households, or the firms are buying the land or they are renting the land that is owned by different people. So, the firms are buying here and when the firms are buying, they will be spending the money that they have.

In this case the rupee is moving from the firms through this market of production into the households. So, the firms are paying the wages, rent and profit. So, if there is labour that is being purchased. So, in exchange for labour the firms will be paying wages. If there is land that has been purchased or rented then the firms will be paying the rent. If there is capital that has been purchased then the firms will be paying for through their profits.

So, in this market for factors of production the firms are buying the factors of production and they are selling or they are paying for it through various rent or profit. On the other hand these factors of production are being made available through the households. So, the households are selling land, labor and capital and in exchange for it they are getting the income.

So, this is a circular flow diagram, because if you look at say the flow of money it moves from households through the market to the firms then through the second market back to the household. So, it completes a complete circle.

On the other hand, if you look at the flow of inputs and outputs, we will find that the inputs and outputs are going through this circle. In both the cases the circle is complete, and so this is the circular flow diagram of an economy.

Packet of milk: identify this transaction on the circular flow diagram. What is Hari in this case? Hari is a part of the household and Hari is paying a dairy for the packet of milk. Dairy is producing and selling this packet of milk. So, the entity that produces and sells goods and services is the firm and the entity that buys these goods and services is the household.

In this example the dairy is the firm and Hari is the household and Hari is paying 60 rupees for this packet of milk. The first thing to understand is whether this is the market for goods and services or whether this is the market for the factors of production. Now, the answer is, in this market the firm is selling things to the household, and so when the firm is selling things to the household it is the market for goods and services.

In this market for goods and services Hari who belongs to the household is spending 60 rupees in this market and the firm which is the dairy is getting a revenue of 60 rupees. And if you look at the flow of inputs and outputs the firm is selling the goods and the goods in this case which is a packet of milk and the household which is Hari is buying this good which is a packet of milk.

Now, where does Hari get this money from? So, Hari earns say 15000 rupees working as a waiter in a restaurant. Now identify this transaction on the circular flow diagram. In this case Hari is earning something, working as a waiter, which means that Hari is providing his labour.

So, he is selling his labour and in return for selling his labor he is getting 15000 rupees. And who is Hari selling this labour to? He is selling this labor to a restaurant. So, in this case the firm is the restaurant or the restaurant is the firm, because firms hire and use the factors of production.

In this case the restaurant is hiding the factor of production which is Hari and using Hari as a waiter. So, the restaurant is the firm, Hari is the household, because Hari is owning and selling the factor of production which in this case is his own labour. This interaction is occurring in the market for the factors of production where the firms buy and the household sell.

Now Hari is selling his labour to the firm, so the firm is procuring the factor of production which is labour. And the 15000 rupees that Hari gets is his income that is deriving from this market of four factors of production and this income is coming through these firms. So, the firms are paying this money in the form of wages.

So, the restaurant is paying wages and these wages become the income of Hari who is the household, a part of the household. So, this is the circular flow diagram.

Now, why is this a model? Why do we call it a model? Because this is a very simplified representation of the working of the economy. The economy is not this simple, because in the circular flow diagram we do not see the government anywhere. So, it does not consider the role of the government.

The government may be providing, maybe collecting taxes, the government may be providing subsidies, the government may be putting certain controls on these markets and on farms and households, but the circular flow diagram is neglecting all of these issues.

It is possible that out of this revenue there is a certain portion that is going to the government. When the households are spending, probably the government is taking the share. When the households are getting income probably there is an income tax that is being paid, but a circular flow diagram is neglecting all of these entry cases and is simplifying things and so this is a model. It also does not consider the role of international trade, because in this model we are considering that this economy only comprises these two entities: the firms and the households.

And we are not considering those goods and services that are being brought from outside. So, it neglects imports and exports.

Another model that we routinely make use of is the production possibilities frontier. Production possibilities frontier is a graph that shows the combinations of output that the economy can prove can possibly produce given the available factors of production and the available production technology.

So, is it a graph or a chart and what does it show? It shows the combination of output that the economy can possibly produce. So, it shows us what the combination of different outputs that the

economy can produce, the constraint of the available factors of production and the available production technology. So, given the available factors of production and given the production technology of the time and phase, what are the different combinations of output that can be produced is shown by the production possibilities frontier.

Now, let us say that there is an economy and for simplicity's sake there are only two goods that can be produced with the technology and with the factors of production. The first good is say computers and the second good is cars. Now, we are simplifying things because we are saying that in this economy, we have only these two items that have been produced. There is no third item because we are trying to understand how the factors of production are allocated.

So we make the simplification that there are only two items. Then the second simplification is that any factor of production can be used in making either of these goods. So, for instance if there is a worker, we can use that worker to produce computers or we can use that worker to produce cars. Now, this again is a big simplification, because in a number of cases the workers who are trained to make computers might not be that trained in making cars, but then this is a simplification that we are using.

Similarly, a number of items that are used in the manufacturing of cars are very different from those that are used in making computers. So, for instance we use silicon in the IC chip that is there in the computers. Now silicon is hardly used in cars. But then when we are making this model of production possibilities frontier, we are saying that any factor of production can be used in making either of these two goods.

Now, suppose the economy decides that we are only going to produce computers. In that case it produces zero cars and it produces 3000 computers. So, that is one production possibility. If you do not make any cars, if you put all your resources into making computers you will make 3000 computers. On the other hand if you put all the resources into making cars you will make say 1000 cars. So, this is the other extreme of this production possibility frontier.

Now, if you spend say 50 percent of your factors of production into making computers and 50 percent into making cars then there will be some other point. If you spend say 10 percent and 90 percent there will be some other point. So, all the points that represent what all things can be manufactured are shown by this line. So, a point such as this will tell us that the economy is currently producing 700 cars and 1200 computers.

Similarly, this point is also possible. All the points that are inside the curve to the left of the curve are also possible, but we say that these are inefficient use of resources, because the resources are not being put to complete use. So, for instance the economy might say that we will be producing say one computer and one car ; however, they could have even produced 700 cars and 1200 computers, but in place of producing 700 and 1200 items they are only producing one. So, that is possible, but that is inefficient.

So, the production possibility frontier tells us the most efficient production of two different goods that the economy can make. Any points that are to the right of this curve are an impossible combination, because the resources and technology are not available to make so many goods or services. So, this is a simplified model that we refer to as the production possibilities frontier.

Now, such a model helps us understand the principles of economies, because here what we are

emphasizing is that the society is facing a tradeoff, what is that trade off? The society wants more cars and more computers, but there is a limit and so the society can either have more computers or it can have more cars. So, it will have to make a tradeoff between computers and cars. The second thing is that tradeoffs are leading to cost and cost is what you give up to get something.

So, in this case you are giving up 3000 computers to make 1000 cars. So, the cost of 1000 cars is 3000 computers or the cost of 3000 computers is 1000 cars. So, this is the cost. So, this model is helping us understand concepts such as tradeoffs and concepts such as cost.

The cost in this case is the opportunity cost. If the society wants more computers it will get less number of cars, and when the society chooses to make only computers the best workers for car production are also used in making computers. But they may not be that good in producing computers, because they are not trained in producing computers which produce the bow shape curve. Putting these workers into car production will not only greatly impact the number of computers produced, but will also greatly increase the number of cars produced.

What we are saying here is that specialization is also being depicted on this curve, because of this shape. Now, in place of producing 3000 computers suppose you could suppose the society produced say 2900 computers. So, we will get a curve like this and the point where this line cuts this curve is this.

So, what we are seeing here is that just by reducing 100 computers we are getting say close to 200 cars why? Because when we are leaving out certain workers from computers into making cars, in a number of cases they will be those workers who are more capable and willing to produce cars, and so we are seeing an effect of specialization.

If the society decides to make only one thing then even those people who are not that specialized to make that item will be used in the manufacturing of that item which will not be the most efficient utilization of resources. So, we are seeing an inefficient utilization of resources when society chooses to make only computers or only cars. So, this is another concept that we are observing through this curve.

Now why is this a model? Because this is a simplified representation of the working of the economy. Almost no economy is there that only produces two goods. Most of the economies produce hundreds of thousands or millions of goods, but then to understand the role of allocation of resources or to understand the opportunity cost or to understand specialization, we have looked at an economic economy that makes only two items.

Similarly, not all factors of production can be equally deployed in making of these two items, but then this is another simplification that we have made, but these simplifications permit an easy grasp of economic ideas of scarcity, efficiency, trade off, opportunity cost and economic growth. How economic growth? Suppose there is the availability of better technology, and so the economy in place of making 3000 computers can now make 4000 computers.

Now, remember that when we started with the production possibility frontier, we said that given the available factors of production and the available production technology. So, this is an assumption in this model. What happens when we break these assumptions? If we say that we make more people available or we say that we make available better technology. So, in that case

the total amount of computers that can be produced now will increase from 3000 to 4000.

Now, when this happens, the curve the production possibility frontier shifts from here to this red line. When that happens now if you look at these two points, earlier the society could have 700 cars and 1200 computers, but now this point is also possible that the society can have 750 750 cars that is more number of cars and 1400 computers that is more number of computers.

Now the economy: this society can have more computers and more cars even though the technology has only increased the number of computers that can be made. Now, this is an example of economic growth. Now in the economic growth more and more people can have access to more and more items. So, in place of this point 700 and 1200 now we have 750 and 1400. This is an example of economic growth.

We can understand economic growth by looking at this production possibility frontier. Next, let us have a look at the economic analysis. Now economics does analysis at two different levels; the first is the level of microeconomics. Microeconomics is the study of how households and firms make decisions and how they interact in the markets. So, in the case of microeconomic analysis we will concentrate on a single firm or we will concentrate on say a single household and we will concentrate on a market in which these are interacting.

In macroeconomics we look at the impacts of all of these different combinations by all the households and all the firms in all the markets. So, macroeconomic phenomena, including inflation, unemployment and economic growth. So, in microeconomics we are looking at things at a micro level at a small level. So, we are asking the question: how do you decide, or how do I decide whether to buy item one or item two? Or how does a firm decide whether to produce item one or produce item two and how much amount to produce? So, questions such as these are asked in the field of microeconomics.

So, it concentrates on either one household or say a firm or on a market. Macroeconomics looks at things from a wider level and it looks at the impact of the interactions and the activities of all the households, all the firms and all the markets in the economy. And so in that case we can understand concepts such as inflation, unemployment, economic growth and so on. Another aspect of analysis is that economics can make use of positive analysis or it can make use of normative analysis.

Now positive analysis is an analysis that claims that the attempt to describe the world is as it is as a scientist; such as minimum wage legislations increase unemployment. So, in this case we are not saying whether this should be done or that should be done. We are just giving things as a matter of fact that in this case minimum wage legislation increases unemployment. This is the fact that we are putting up, so this is a positive analysis. A normative analysis claims to attempt to prescribe how the world should be as a policy advisor.

If I say the same sentence and if I put it as minimum wage legislations should be removed when I am talking about a normative analysis. Because I am talking about the way things should be, it should be removed. Now, all that being said there are certain field realities also that we need to be aware of. Economic advice is not always followed, sometimes other considerations such as votes or private profits or lethargy may hold sway.

If there is an economic analysis that says that minimum wage legislations should be removed, it

does not mean that the minimum wage legislations will be removed, because you also have to look at other factors; such as politics or the level of society of that area and so on. The second thing is that the economists themselves disagree a lot why? Because of differences in which scientific theory to follow, differences in their value judgments. Example whether to choose efficiency or equality because in a number of cases the economists themselves are doing a normative analysis.

For instance a person who puts much faith in increasing efficiency might say that minimum wage legislation should be removed. On the other hand another economist who emphasizes on the level of or on the quality of life of these labourers might say no; minimum wage legislations are extremely important otherwise these people might get exploited.

Now, both of these economists are correct in their own opinions. They are correct in their own places, but they have a difference in the value judgments, whether they are trying to emphasize the efficiency of the economy or whether they are trying to emphasize the level of equality that is there in the society.

So, these are certain reasons because of which the economist might themselves disagree. So, you have to take everything with a pinch of salt. So, in this lecture we had a look at how an economist thinks, what are the different kinds of models, what are the different kinds of analysis that we make use of, certain terms that belong to the screen and so on.

That is all for today. Thank you for your attention. Jai Hind!

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Module 5
How can Economics help?
Lecture 3
Interdependence and gains from trade

Namaste!

We carry forward our discussion. And in this lecture, we will explore Interdependence and Gains from Trade. One question in economics that we should think about is why should people go for a trade. If I can do everything by myself should I not be doing everything by myself or are there certain advantages that I can gain by going for a trade, that is I do something, you do something, I give something to you, and you in return give something to me. So, that is trade.

And we begin this lecture by exploring what Adam Smith had said about trade. Why trade? It is a maxim of every prudent master of a family, never to attempt to make at home what it will cost him more to make than to buy. So, here Adam Smith is saying that for any prudent master of a family.

Remember that we had said that in economics we consider that everybody is a rational person. So, if somebody is rational, if somebody is prudent then what the prudent person does is that he or she never attempts to make at home what it will cost him more to make than to buy, which means that if suppose you can make potato chips at home or you can buy it from outside. Now, if you can make potato chips and if it is costing you 100 rupees for 1 kg of potato chips.

But when you go to the market you can find it for say 80 rupees. So, in that case it makes more sense to buy it from the market. So, it is a maxim of every prudent master of a family never to attempt to make at home, what it will cost him more to make than to buy. The tailor does not attempt to make his own shoes, but buys them of the shoemaker. Why? Because the shoemaker probably is able to make it at a cheaper cost especially because the shoemaker is in the profession of making the shoes.

He has all different kinds of equipment, he has sufficient training that is required to make the shoes. Now, because of having better equipment, because of having better training, the shoemaker is able to make a shoe for much cheaper than what it would have required the tailor to make a shoe.

So, the tailor does not attempt to make his own shoes, but buys them from the shoemaker. The shoemaker does not attempt to make his own clothes, but employs a tailor. Why? Because here again for making clothes it will require a very different set of equipment, it will require a very different set of training. And probably the tailor has those equipment, probably the tailor has that

training because of which he is in a much better position to make clothes much cheaper. In this case the shoemaker buys the clothes from the tailor. He does not attempt to make the clothes by himself. The farmer attempts to make neither the one nor the other, but employs those different artificers. That is the farmer when he has to buy shoes, he goes to the shoemaker. When he wants to have clothes, he goes to the tailor. He does not attempt to make shoes or attempt to make the clothes because he is not a specialist, he does not have the equipment, he does not have the training.

And if he tried to make clothes or shoes then probably it will cost him much more than buying it from the market or from the tailor or from the shoemaker. Especially because in the case of a number of articles the equipment that is required are costly. So, probably the former can buy a pair of shoes for say 500 rupees.

But the equipment that is needed to make those shoes probably costs say 2 lakhs of rupees. Now, in that case it does not make any sense for the farmer to buy these equipment for 2 lakhs of rupees when he can buy a pair of shoes for just 500 rupees. So, this is what Adam Smith is saying. The farmer attempts to make neither the one nor the other, but employs those different artificers. All of them find it for their interest to employ their whole industry in a way in which they have some advantage over their neighbours. So, everybody finds it in their own interest to employ their own industry, that is to devote their time and to devote their effort in something in which they have an advantage over their neighbours. And to produce with a part of its produce.

And to purchase with a part of its produce or what is the same thing with the price of part of it, whatever else they have occasion for. So, it is in the interest of everybody to spend their time and effort in something in which they have an advantage over their neighbours.

So, the tailor is spending his time and effort in making clothes because he has an advantage over the shoemaker and over the farmer in making clothes. So, if he makes clothes much more cheaply or in other words on any particular day he can make many more clothes than could be made by say the shoemaker or the farmer. So, in this case the tailor has an advantage over his neighbours in making clothes. Similarly, the shoemaker has an advantage over the tailor and the farmer in making shoes.

So, it is in the interest of everybody to employ their whole industry in a way in which they have some advantage over their neighbours. But because you require other things as well because the tailor requires shoes. So, what will he do? He will produce an excess of cloth he will then give these clothes to his neighbours.

And in exchange he will get the shoes or the food grains. So, he will purchase with a part of its produce which means that he is having an excess of cloth and he will use some part of this production that is these excess of clothes to purchase the other things. Now, in place of giving clothes the other way out is that he can use the price mechanism. So, with it he gives a cloth or whether he sells those clothes and gives the money is one and the same thing.

To purchase with a part of its produce or what is the same thing with the price of part of it whatever else they have the occasion for. Whatever else he wants to purchase he will use his excess clothes or he will use the money that he is getting from selling these excess clothes to purchase whatever else he needs.

Now, this is something that we observe on a day to day basis. So, nobody tries to do everything because it is in their own self-interest. But what this small story is telling us is a few salient points. People do not make anything or do not do something in which case it will cost them more to make than to buy. So, this is the first thing. If there is something that you can procure at a cheaper cost than that of making then probably you will go for procuring it. And why do people do that? Why? Because people are rational beings.

So, any rational person would try to maximize his or her own resources. And so, if he or she can get something cheaply from some other place then they would prefer to get it than making everything by themselves. And why are they doing it? Because they are finding it in their interest.

In this case what Adam Smith is hinting is that they are not doing it because of a benevolence. So, the tailor when he is giving the clothes to the shoemaker in exchange for a pair of shoes, he is not giving these clothes by means of benevolence, he is not trying to help out the shoemaker. He is acting in his own interest. So, when we talk about trade it is in the interest of everybody and nobody is doing it for benevolence. So, all of them find it for their interest.

And what do they do? They do something in which they have some advantage over their neighbours. So, he is hinting that if there is an advantage that could be an absolute advantage or a comparative advantage. But if you have an advantage over your neighbours in doing something. Then you should be doing that and not doing things in which you do not have an advantage because you are thinking rationally. Now, it is easy to understand trade if one person can only make one kind of good. So, if we have a situation in which it is only the tailor who can make clothes, the farmer cannot make any clothes, the shoemaker cannot make any clothes, and the shoemaker can make shoes, but the tailor cannot make any shoes the farmer cannot make any shoes because of whatever reason.

So, it could be that in this society it is prohibited for any person other than a tailor to make a cloth. Now, if you have a situation such as this then no doubt trade is inevitable because there is no way out that a tailor could have access to shoes other than by the means of trade because it is prohibited for him to make shoes. Or probably the only sewing machine in the society resides with the tailor and he says I am not going to give it to anybody else.

In such a situation there is no way that the shoemaker would have access to clothes, if he did not trade with the tailor. So, what we are saying here is that if there are say 2 farmers and there are 2 goods, one is milk the other good is potatoes. Now, farmer 1 can produce any amount of milk in a day, but he cannot produce any potatoes and farmer 2 which is shown in this green color can make any amount of potatoes, but he cannot produce any milk.

So, what happens in this case? There is no way for farmer 1 to have access to potatoes if he does not get them from farmer 2, and similarly there is no way farmer 2 can have access to any amount of milk if he or she is not trading with farmer 1. So, if one person can make one sort of good and no other person can make that particular good then trade is inevitable. There is no way that trade would not happen in such a society. But the question is in the real world we do not find such a situation.

So, in a number of cases we can observe that a farmer can produce milk because he or she can have few cattle in his home or the farmer can produce potatoes as well. Now, the question is will

they still trade if they can make both the things. So, we have a situation like this. So, we are saying that the farmer 1 can produce milk, but he is much better at producing milk than potatoes. Whereas, farmer 2 can produce potatoes he can also produce milk, but he is much better at making potatoes than milk.

Now, in this case what we are saying is that these farmers have different absolute advantages, that is the farmer 1 if he spends his time in producing milk then he can make much more amount of milk in a day than farmer 2. So, suppose both farmer 1 and farmer 2 decided that they are only going to produce milk. So, in that case farmer 1 will be producing this much amount of milk and farmer 2 will be producing this much amount of milk.

So, what we are seeing here is that farmer 1 has an absolute advantage in the production of milk. And similarly farmer 2 has an absolute advantage in the production of potatoes because farmer 2 can make this much amount of potatoes in a day, whereas farmer 1 could only produce this much amount of potatoes in a day.

So, if there is a difference in absolute advantages. What is the absolute advantage? The ability to produce a good using few inputs a fewer inputs than another producer. So, in this case, what we are observing is that to produce a quantum of milk. So, let us say that both the farmers have only 8 hours in a day in which they can work.

Now, let us suppose that farmer 1 can make say 8 litres of milk in a day, so in an hour he can make 1 litre of milk. Whereas, farmer 2 can only make 2 litres of milk in a day. So, what we are hinting here is that for farmer 1 he can make 8 litres of milk in 8 hours. And farmer 2 can only make 2 litres of milk in 8 hours.

So, this much is 8 litres of milk and this much is 2 litres of milk. Now, this would mean that to make 1 litre of milk the time required is 8 hours divided by 8 or 1 hour. Now, the input that is required to make 1 litre of milk in this case is 1 hour in the case of farmer 1. Whereas, in the case of farmer 2 what we are observing is that to make 1 litre of milk.

The farmer requires 8 hours divided by 2 litres which is 4 hours. So, in this case what we are observing is that farmer 1 can make 1 litre of milk using fewer inputs: just 1 hour of input whereas, farmer 2 can make 1 litre of milk using a larger amount of inputs that is 4 hours. So, in this case, the farmer 1 has an absolute advantage because he has the ability to produce a good, in this case the good is 1 litre of milk using fewer inputs than another producer.

Well, in this case the input is the time that the farmer is putting in. So, farmer 1 has an absolute advantage in milk production. Now, similarly in the case of potato production we will find that farmer 2 has an absolute advantage because let us say that the farmer 2.

Let us suppose that this much is 24 kg of potatoes and he is making 24 kg of potatoes in 8 hours. Whereas farmer 1, if he spends all his time all the 8 hours in making potatoes then probably he is able to produce only 4 kgs of potatoes in 8 hours. (Refer Time: 17:20) when there is one farmer who has an absolute advantage over both the goods.

Now, in this figure what we are observing is that the production possibility frontier for farmer 1 is here in red and for farmer 2 is here in green. Now, in this case when both the farmers are only producing milk, then farmer 2 can make 24 litres of milk in 8 hours, whereas farmer 1 can only produce 8 litres of milk in 8 hours.

Here we are observing that farmer 2 has an absolute advantage over farmer 1 in the production of milk, that is we can make milk using fewer inputs. In this case, if you look at the time that would be required, so for farmer 2 in 8 hours he can make 24 litres of milk which means that to make 1 litre of milk he requires $8 \text{ by } 24 = 0.33$ hours Now, this is the input in terms of time that he requires to make milk 1 litre of milk. Whereas, farmer 1 for him in 8 hours he is making 8 litres of milk.

To make 1 litre of milk he requires $8 \text{ by } 8 = 1$ hour. Now, in this case, it is easy to see that farmer 2 has an absolute advantage over farmer 1 because he can make the good in this case 1 litre of milk using fewer inputs that is just one-third of an hour as compared to the second as compared to farmer 1. So, farmer 2 has an absolute advantage here farmer 2 has absolute advantage. Now, this is for milk production. Now, let us look at potato production.

Now, in this case farmer 2 in 8 hours if he only produced potatoes he would have made 48 kg of potatoes. So, to make 1 kg of potatoes he requires $8 \text{ by } 48 = 1 \text{ by } 6$ hours or 10 minutes. Now, let us look at farmer 1. Farmer 1 in 8 hours if he only produced potatoes he would have produced 32 kgs of potatoes, which means that to make 1 kg of potatoes he requires $8 \text{ by } 32 = 0.25$ hours which is 15 minutes. Now, in this case, when we talk about potato production.

Farmer 2 requires 10 minutes and farmer 1 requires 15 minutes. So, here again we are observing that farmer 2 requires less inputs, he requires only 10 minutes of input, whereas farmer 1 requires 15 minutes of input. So, in this case farmer 2 has an absolute advantage. So, what we are observing here is that when we talk about potatoes, farmer 2 has an absolute advantage, when we talk about milk farmer 2 has an absolute advantage. So, farmer 2 in this case is having an absolute advantage.

In both these goods potatoes as well as milk. So, now the question is if farmer 2 is more efficient at producing potatoes and he is more efficient in producing milk as well, should he go for a trade. Does it make any sense for both of these farmers to go for a trade? And that is the question.

And as we will see, yes, here again there is an advantage. Then both of them went for a trade. So, here we come to the concept of comparative advantage. So, absolute advantage as you remember is the ability to produce a good using fewer inputs than another producer and in this case farmer 2 has an absolute advantage over farmer 1 over good the goods. But then there is a difference in comparative advantage. Comparative advantage is the ability to produce a good at a lower opportunity cost than another producer.

Comparative advantage is the ability to produce the good at a lower opportunity cost, not using fewer inputs, but at a lower opportunity cost than another producer. And in this case, opportunity cost is defined as whatever must be given up to obtain some other item. So, if we look at this curve again, farmer 2 could produce 24 litres of milk in 8 hours.

If he devoted his time completely to the production of milk. Or he could have made 48 kgs of potatoes, if he spent all his time making potatoes which means that for farmer 2, 24 litres of milk is equivalent to 48 kgs of potatoes. And for farmer 1, he could have spent his 8 hours either to make 8 litres of milk or to make 32 kgs of potatoes.

Now, which means that for farmer 1, the milk production could be as high as 8 units. So, farmer 1, the milk production is as high as 8 units and the potato production is as high as 32 kgs. The

potato production is 32 kgs. So, the opportunity cost for 1 unit of milk production is 32 by 8 which is 4 units of potatoes. So, this is the opportunity cost. What is he giving up? To make 8 units of milk he is giving up 32 units of potatoes. So, to make 1 unit of milk, he is giving up 32 divided by 8 is 4 units of potatoes.

So, this is the opportunity cost for farmer 1 for 1 unit of milk production. And similarly, the opportunity cost for 1 unit of potato production is 8 units of milk divided by 32 is 0.25 units of milk. So, these are the opportunity cost for farmer 1. The opportunity cost for 1 unit of milk is 4 units of potatoes and the opportunity cost for 1 unit of potato is 1 by 4 or 0.25 units of milk. Now, similarly for farmer 2 he could have made 24 units of milk or 48 units of potatoes.

If farmer 2 devotes all his time for milk production, he makes 24 units. If he spends all his time on potato production, he can have 48 units of potatoes. So, the opportunity cost for 1 unit of milk production is how much amount of potatoes is he giving up to make 1 unit of milk, to make 24 units of milk he is giving up 48 units of potatoes because when he is devoting all his 8 hours into milk production he is having 0 units of potatoes. So, he is giving up 48 units of potatoes.

To make 1 unit of milk he is giving up 48 by 24 is 2 units of potatoes. And similarly, to make 1 unit of potatoes he is giving up 24 by 48 is 0.5 units of milk because to make 48 units of potatoes he is giving up 24 units of milk. So, to make 1 unit of potato, he is giving up 24 by 48 is 0.5 units of milk.

Now, if we make a table of the opportunity cost of both of these farmers. For farmer 1, we have seen that the opportunity cost for milk is 4 units of potatoes. So, the opportunity cost for 1 unit of milk is 4 units of potatoes and the opportunity cost for making 1 unit of potato is 0.25 units of milk, which we are writing here is 0.25 units of milk.

For farmer 2, the opportunity cost for making 1 unit of milk is 2 units of potatoes, 2 units of potatoes here and the opportunity cost for making 1 unit of potato is 0.5 units of milk which we write here 0.5 units of milk. Now, if we look at farmer 1, he has a comparative advantage in producing potatoes because to make 1 unit of potato he needs to give up only 0.25 units of milk whereas, farmer 2 would have to give up 0.5 units of milk.

So, farmer 1 is giving or he is leaving out only 0.25 units of milk for 1 unit of potatoes, whereas farmer 2 has to give up a lot more, double the amount to make 1 unit of potato. So, farmer 1, we can see that he has a comparative advantage for potato production. And similarly, when we talk about milk production farmer 2 will have to give up only 2 units of potatoes for 1 unit of milk, whereas, farmer 1 would have to give up 4 units of potatoes.

Farmer 2 has a comparative advantage when it comes to milk production because he has to give up only 2 units of potatoes whereas, farmer 1 would have to give up 4 units of potatoes. So, farmer 2 has a comparative advantage for milk production. So, here even though farmer 2 was having an absolute advantage in both potato production as well as milk production, what we are observing is that while farmer 2 has a comparative advantage for milk production.

He does not have a comparative advantage for potato production. Farmer 1 has the comparative advantage. Now, in the case of trade, people can go for a trade because they have different comparative advantages. And so, if they go for a trade then it will be for their own mutual advantage. Through trade they can get the product at a cost lower than their own. So, here again what we are

observing is that if somebody can get something from the market at a cost that is lower than his or her own cost of production.

Then it is to their own advantage to take it from the market. Which means that they should go for a trade because through trade they will be able to get these 2 items: milk and potatoes at a cost that is lower than what they would have cost to make at home. So, the farmer 1 who has a comparative advantage for potato production should produce more potato than what he needs and the excess he should sell to the market in exchange for milk.

And the farmer 2, because he has a comparative advantage for milk production should produce an excess of milk than his own requirements and sell the excess in the market in exchange for potatoes. So, trade promotes specialization in activities where people have a comparative advantage.

It is to the advantage of both the parties that they should be making things for which they have a comparative advantage. Never to attempt to make at home, what it will cost them more to make than to buy, in their own interest and in things in which they have some advantage over their neighbours.

So, this maxim from Adam Smith is what actually drives the trade. So, the question is, suppose there is a heart surgeon who also happens to be the fastest typist in the world. Should he type himself or should he hire someone else? And why? Now, the question is whether there is a heart surgeon who has an absolute advantage in both heart surgery as well as in typing because he can type fastest in the whole world. So, he can type faster than any other typist.

But then even though he has an absolute advantage, he would be having a comparative advantage in only one of these two fields. And so, he should not do the typing himself, he should hire someone because he has a comparative advantage in heart surgery and if he has a competitive advantage in heart surgery, he probably does not have a comparative advantage in typing. So, for instance, in one hour if he was doing a heart surgery, say he was earning 10000 rupees, but he could hire a typist for say 100 rupees for an hour.

So, if he is giving up heart surgery or he is giving up 1 hour that he could have given to heart surgery and if he is typing by himself then probably he is not doing prudently. He is not acting rationally. So, trade can make everybody better off because it permits you to do things where you have a comparative advantage.

And for things where somebody else has a comparative advantage you take those goods or services from that person. So, here the heart surgeon should not be doing the typing himself. He should be hiring a typist, even though he has an absolute advantage when it comes to typing.

Now, the next question is what should be the price of trade? That is at what rate should 1 unit of milk be exchanged in the market for potatoes. Now, remember that people were going for trade because it was in their own advantage, they were acting in self-interest, they were not acting in benevolence.

So, nobody is doing a trade to benefit the other party. They are getting into trade because it is to their own advantage. Now, if we talk about the cost of making milk for farmer 1 the cost of making milk is 4 units of potatoes. Now, if somebody says that he should give up 6 units of potatoes for 1 unit of milk would he agree? And probably not. Why? Because he would say that if I can

get a unit of milk from 4 units of potatoes why should I pay 6 units of potatoes?

But if somebody says that ok, we are going to offer you 1 unit of milk for say 3 units of potatoes, then this farmer would think, ok if I made 1 unit of milk myself it would have cost me 4 units of potatoes. But in the market I am getting it for 3 units of potatoes. So, probably it's good for me. Probably I should take up this offer.

Now, similarly when we talk about farmer 2 to make 1 unit of milk he is sacrificing 2 units of potatoes. So, that is the opportunity cost for 1 unit of milk on this farmer 2. Now, if in the market he gets this offer that to get 1 unit of milk you should give up 3 units of potatoes. Now, would this farmer agree?

Well, probably not. Because he would again say that I can make 1 unit of milk myself by just 2 units of potatoes, why should I pay 3? But if he gets an offer of 1 unit of milk from just 1 unit of potatoes he would agree because it is costing him 2 units of potatoes, if he can get it for 1 unit of potatoes he will be happy.

There is a price at which farmer 1 is happy which is if he gets it at anything less than 3, anything less than 4, there is a price at which farmer 2 is happy and is agreeable, if he is getting it for anything that is less than 2. So, there are different prices at which both of these farmers can agree. And similarly, for 1 unit of potato, if farmer 1 can get 1 unit of potato for anything that is less than 0.25 units of milk, he would agree because it is to his advantage.

Similarly, for farmer 2, if he gets 1 unit of potato for anything less than 0.5 units of milk he would agree because it is costing him 0.5 units of milk. If he can get 1 unit of potato from the market at a lesser cost then probably he will go for it. Now, for both the parties to gain from the trade the price must lie in between these 2 opportunity costs.

So, suppose we decide that the price is 3 units of potatoes for 1 unit of milk. So, here 1 unit of milk was costing farmer 1, 4 units of potatoes and farmer 2, 2 units of potato. We take something in between. So, we take 3 units of potatoes for 1 unit of milk. Now, if this happens would these 2 farmers agree to go for a trade as we are interested in knowing?

Now, to understand the impact of trade let us also consider that earlier the farmers were devoting half their time to producing milk and half their time to producing potatoes, that is they were spending 4 hours in producing milk and 4 hours in producing potatoes. So, what was the situation before the trade?

Now, here we are looking at farmer 1 and farmer 2 production and consumption without gain. Now, before these 2 farmers were entering into trade, the amount of milk and the amount of potatoes that they were producing was also the amount that they were consuming because they are not getting anything from outside and they have all what they are producing for themselves. So, the amount of production is equal to the amount of consumption.

Now, for farmer 1, he was devoting 4 hours to make milk and 4 hours to make potatoes. Now, for farmer 1, in 8 hours he could produce 8 units of milk, so in 4 hours he will be producing half of that which is 4 units of milk. And in 8 hours he could have produced 32 units of potatoes, so in 4 hours half of that he would be producing half of 32 which is 16 units of potatoes which is what we are seeing here. If he only makes milk for 4 hours he gets 4 units of milk and in 4 hours he is getting 16 units of potatoes.

Now, in the case of farmer 2, if he devoted 8 hours for milk he made 24 units of milk. Now, if he devoted only 4 hours he would be making half of that which is 24 by 2 is 12 units of milk which is what we are seeing here. In 4 hours he is producing 12 units of milk.

And in 8 hours he could have produced 48 units of potatoes and so, in 4 hours he would be making half of that 24 units. So, this is what we are seeing here. He is making 24 units of potatoes in 4 hours. So, because the amount of production is also equal to the amount of consumption.

So, here farmer 1 is consuming 4 units of milk and 16 units of potatoes, and farmer 2 is consuming 12 units of milk and 24 units of potatoes. Now, here again what we are seeing is that the farmer too has an absolute advantage over both milk and potatoes, and so, he is consuming more milk and he is consuming more potatoes as compared to farmer 1. Now, when they go for trade and in the case of trade the price is decided as 3 units of potatoes for 1 unit of milk.

Now, what happens? Now, suppose farmer 1 because he has a comparative advantage in making potatoes. So, we saw it here, that to make 1 unit of potato he has to give up 0.25 units of milk, whereas farmer 2 would have to give up 0.5 units of milk. So, he has a comparative advantage in the production of potatoes. So, farmer 1 decides that I will spend all my 8 hours making potatoes. So, he is spending all 8 hours for potatoes and so, he has 0 hours for milk.

Now, in 8 hours farmer 1 can produce 32 units of potatoes, so which is what we are seeing here. So, he is producing 32 units of potatoes and 0 units of milk. Now, farmer 2 has a comparative advantage when it comes to milk production. So, in the case of milk, farmer 2 has the cost of 2 units of potatoes for a unit of milk, whereas farmer 1 has 4 units of potatoes for 1 unit of milk. So, farmer 2 has a comparative advantage. Now, in this case, suppose farmer 2 decides that I will spend 6 hours making milk.

And only 2 hours to make potatoes. Now, here again it is important to note that when we are talking about trade we are not saying that you should only be doing things where you have comparative advantages. You can even be doing things where you do not have a comparative advantage because probably the market is not able to supply you with all the things that you need. So, in that case even though it is not a comparative advantage you could be making certain things.

But here what farmer 2 is saying is that because he has a comparative advantage for milk production, he is devoting a larger amount of time for milk production and a very small amount of time for potato production. Now, in 6 hours what is the amount of milk that he will be producing? In 8 hours he makes 24 units of milk.

So, in the case of farmer 2, in 8 hours he makes 24 units of milk which means that in 1 hour he would make 24 by 3 by 8 is 3 units of milk, and in 6 hours he would be making 3 into 6 is 18 units of milk. So, in 6 hours he is making 18 units of milk. And he is only spending 2 hours on potato production.

Now, in this case what we are saying is that when we talk about potato production, farmer 2 in 8 hours could have made 48 units of potatoes. So, in 1 hour he would have made 48 by 8 which is 6 units of potatoes. So, in 2 hours he makes 6 into 2 which is 12 units of potatoes, which is what we are putting here.

So, in 2 hours he is making 12 units of potatoes. So, once they have agreed to go for trade this is the amount of items that these farmers are producing. Farmer 1 is producing 0 units of milk and

32 units of potatoes, farmer 2 is producing 18 units of milk and 12 units of potatoes.

Now, they have decided that the price is 3 units of potatoes for 1 unit of milk. Now, suppose they are going for this trade. So, 1 unit of milk is 3 units of potatoes. So, farmer 1 decides that he will give 15 units of potatoes to farmer 2. So, here because of trade he is giving up 15 units, so we are writing it as minus 15 and farmer 2 is getting 15 units of potatoes. So, we are writing it as plus 15. Now, because the price of potatoes is 3 units of potatoes is 1 unit of milk.

So, 1 unit of potato is 1 by 3 units of milk, 3 units of potatoes is equal to 1 unit of milk which means that 1 unit of potatoes is equal to 1 divided by 3 units of milk. So, 15 units of potatoes is equal to 1 by 3 times 15 which is equal to 5 units of milk. Now, with this price 3 units of potatoes is 1 unit of milk 15 units of potatoes is equivalent to 5 units of milk. So, because farmer 1 was giving 15 units of potatoes to farmer 2, he will be getting 5 units of milk in return.

So, farmer 2 is giving 5 units of milk. So, we are writing it as minus 5 and farmer 1 is getting 5 units of milk which we are writing as plus 5. So, what is the consumption after the trade? Now, for farmer 1 he was not producing any milk, but he is getting 5 units of milk from farmer 2. So, the total unit that he has now is 5 units 0 plus 5. He was producing 32 units of potatoes, he gave up 15 units of potatoes to farmer 2 and so, he is left with 17 units of potatoes.

So, the consumption after trade for farmer 1 is 5 units of milk and 17 units of potatoes. Now, similarly for farmer 2 he was making 18 units of milk, he gave up 5 units to farmer 1 and so, he is left with 13 units of milk. And he was making 12 units of potatoes. He got 15 units from farmer 1, and so now, he has 27 units of potatoes.

Now, what is the gain from trade? Is there any increase in consumption or is there a decrease in consumption? So, earlier without trade farmer 1 was having 4 units of milk after trade he had 5 units of milk. So, there is an addition. So, because of this trade he can consume one extra unit of milk. What about potatoes earlier? He was consuming 16 units of potatoes, now he is consuming 17 units of potatoes which means that the potato consumption has also increased.

So, here farmer 1 is consuming more of milk and more of potatoes because of the trade which means that farmer 1 has added to his well-being he has added to his advantage. Earlier he was consuming less milk and less potatoes, now he is consuming more milk and more potatoes. What about farmer 2? Earlier he was consuming 12 units of milk, now he is consuming 13 units of milk which means that he has an advantage of plus 1. So, he is now consuming more milk.

What about potatoes? Earlier he was consuming 24 units of potatoes, now he is getting 27 units of potatoes to consume. So, now, he has an advantage of plus 3 units. So, he is consuming 3 extra units of potatoes than what he was consuming before the trade. Even in the case of farmer 2, he is now consuming more milk and more potatoes. So, it is adding to his well-being or his welfare as well. So, what we are observing here is that because of trade both farmer 1 and farmer 2 have increased their consumption.

They are now having more resources. So, trade has added to the benefit of both of these parties. Trade has benefited farmer 1 and it has also benefited farmer 2, which means that when we said that the trade increases the welfare of all the parties involved this is an example of that.

Now, how can this trade happen? This trade can occur in 2 ways. There could be a barter system. Now, in the case of a barter system what happens is that both of these parties come to the market

and they exchange these goods with each other. So, for 3 units of potatoes they exchange it for 1 unit of milk. So, both these farmers will go to a market with their produce of potatoes and milk that they want to trade, and there they will be exchanging these two amongst themselves.

The other way is through a market using currency. So, this trade can occur through a barter system or in a market. And in the next module we will have a look at the markets. So, essentially what we are seeing in this lecture is that we began with this thing from Adam Smith that if you can get something cheaply from the market then what it costs you to make at home you should probably get that thing from the market. Because rationally it would be to your own benefit, it would be in your own interest.

And this interest or this sort of a trading helps people to do those things where they have an advantage over their needs. Now, this advantage could be an absolute advantage or a comparative advantage. So, we observed that if we have a society where one good can only be made by one person and the other good can only be made by the second person, then of course, trade is inevitable because if the first person wanted to have access to the second thing he could only get it through means of trade.

Trade is also very obvious if both the parties have an absolute advantage over something. So, if farmer 1 has an absolute advantage in production of milk and farmer 2 has an absolute advantage in the production of potatoes, then trade becomes obvious. And here we define absolute advantage as the ability to produce a good using fewer inputs than the other producer. So, absolute advantage means that you are requiring less amount of inputs than the other producer probably because you are more efficient.

So, the absolute advantage is talking about efficiency. But then even in cases where you do not have an absolute advantage then to trade makes sense if there is a difference in the comparative advantage. And comparative advantage is the ability to produce a good at a lower opportunity cost than the other producer.

Where opportunity cost is defined as what must be given up to obtain some other item. Now, the concept of comparative advantage is important because even though a person has an absolute advantage in doing one or more of things, he may not be having a comparative advantage over all of them. Because there are some activities that pay at a much greater rate than some other activities. And we looked at the example of a heart surgeon who is also a very good typist.

Now, if he is doing heart surgery he can earn much more per hour than when he can do it when he is typing. So, it makes much more sense for the heart surgeon to devote his time to heart surgery, earn a lot more and then spend a part of it to hire a typist. So, comparative advantage tells us why even though there could be some people who have an absolute advantage in doing many things, they should still go for a trade and trade is still going to make them better off.

Next, we had a look at this case where there is a farmer who has an absolute advantage over 2 goods, both milk production and potato production. And we saw the opportunity cost for both of these farmers for both of these goods. And when we look at the opportunity cost.

We will find that there is some good for which there is a greater comparative advantage for one party than the other party. Now, of course, if both of these farmers were making things at a proportional rate that is if both of these curves were parallel to each other then it is also possible that

there is no party who is having a comparative advantage because say farmer 2 was producing 24 units of milk or 48 units of potatoes and farmer 1 was producing either 8 units of milk or 16 units of potatoes.

So, in that case, the ratio would have been the same for both the farmers 24 by 48 is 0.5 and 8 by 16 is 0.5. And in that case, the opportunity cost for these items would have been the same for both these parties, but then in a real life situation we do not just have 2 parties, we have multiple parties. So, in that case, there would have been some other person who would be having a difference of opportunity cost. So, when we talk about markets we talk about a number of buyers and a number of sellers.

So, which makes trade even more lucrative. But in this case what we observed was that there was a difference in the opportunity cost. So, while farmer 1 was having a comparative advantage for potato production because for 1 unit of potato he was costing him 0.25 units of milk.

Whereas, for farmer 2 it was costing him 0.5 units of milk. So, farmer 1 was having a comparative advantage for production of potatoes. Similarly, farmer 2 was having a comparative advantage for the production of milk because it cost him only 2 units of potatoes whereas, it cost farmer 1 4 units of potatoes.

So, farmer 2 has a comparative advantage for milk production. And in such a case, it is to the benefit of both of them that it is in their own interest to buy things from the market that are available at a cost that is lesser than their own opportunity cost. And so, we can say that they should spend their time doing what is providing them a greater advantage over their neighbours. And here we observed that if they decide at a price that is in between both of these opportunity costs. In our example they had decided that it should be 3 units of potatoes for 1 unit of milk or in other words 1 by 3 units of milk for 1 unit of potato. So, 1 unit of potatoes is equal to 1 by 3 units of milk which is 0.33 units of milk. Now, we can observe that 3 is between 4 and 2, and 0.33 lies between 0.25 and 0.5. So, if they come to a figure that is in between their opportunity cost then that could be a good price point at which they can trade.

And when they do this trading we observe that they are increasing their consumption of both milk and potatoes. So, there is a gain of trade for both the parties, which is what we had observed in the 10 principles of economics. Trade can make everyone better off. So, that is a short introduction about what is trade and why people go for trade.

And as we will observe in the later lectures, this trade can have a very important ramification for conservation because people might even go for a trade for those items that harm the environment. We will build upon this topic in the later lectures.

That is all for today. Thank you for your attention. Jai Hind!

Conservation Economics
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Module 6
Markets: Places where Economics works
Lecture 1
Demand and supply

Namaste! Today, we begin a new module which is Markets, Places where Economics works. This module we will have three lectures - demand and supply, elasticity, and government policy. So, let us begin with Demand and supply.

A market is defined as a group of buyers and sellers of a particular good or service. So, it is a group of buyers and sellers. It is not just a single buyer and a single seller; it is a group of buyers and sellers. You cannot have a market with only buyers, or you cannot have a market with only sellers.

It has to be a market of or a group of buyers together with the sellers of a particular good or service which means that there can be different markets for different goods and services. So, for instance, we can have a market for food grains, we can have a market for goods, we can have a market for selling and buying stocks and so on. So, it is a group of buyers and sellers of a particular good or service.

Now, buyers determine the demand for a product and sellers determine the supply for the product. So, buyers are those who are asking for the product, they want to purchase these products. So, they create a demand in the market. So, the more the number of buyers, the greater will be the demand. Similarly, the sellers determine the supply in the market because the sellers are the suppliers of the good or service.

If there are more sellers or if each seller decides that your need is going to supply more amounts of these goods and services, then the supply in the market will go up. So, buyers determine the demand for a product and sellers determine the supply for the product.

And there are different kinds of markets. You can have an organized market such as the market for a food grain. So, in the case of an organized market, different buyers and sellers come to a place and they play by certain rules to sell their products. In a number of these organized markets, the buying and selling of goods could be through the use of auctions or through certain other institutional mechanisms. So, this is an organized market.

On the other hand, you can also have certain unorganized markets such as ice cream shops. Now, in the case of an ice cream shop, there is no fixed procedure for buying or selling. We do not have an auction, you just go to an ice cream shop, you pay the money and you get the ice cream. So, this is an unorganized market. We are not seeing any sort of an organization of different buy-

ers or different sellers who are coming together for meeting a specific purpose. So, this is an unorganized market. Similarly, the market may be competitive, or it may be uncompetitive.

A competitive market is defined as a market in which there are many buyers and many sellers, so that each has a negligible impact on the market price. A market in which there are many buyers and many sellers, so that each has a negligible impact on the market price. So, what we are referring to here is that in a competitive market there are several buyers, and so the buyer is unable to determine the market price.

Suppose, there were only a few buyers or let us say that there was only a single buyer. Now, the amount of money that this buyer is able and willing to spend in the market that would determine the price of the products, because if say the buyer goes to a market and says that I can only pay 100 rupees for this particular product.

Now, in that case, there is no way in which any seller would be able to sell it for more than 100 rupees because there is only a single buyer. Now, similarly, if there is a single seller, in that case the rate at which the seller is ready to sell that would be the market price.

But, in the case of a competitive market, we have many buyers and we have many sellers, so that any one buyer or seller is unable to determine the market price. So, for instance, if our buyer is there and he is ready to pay say 100 rupees or say 1 kg of price; and if there is another buyer who is ready to pay 105 rupees. So, in this case, the buyer who was ready to pay 100 rupees, he is not able to change the market price.

Similarly, if you have a number of sellers, the seller who sells at the lowest price would be determining the market price, but other sellers will not be determining the market price. So, in a competitive market, the buyer who pays the largest price at the seller who sells at the lowest price determines what would be the market price. Any other buyer or seller is unable to determine the market price, because they do not have the power to change the market prices or to increase the market prices.

Other characteristics of perfectly competitive markets include things such as goods that are offered for sale are exactly the same. Which means that if you have, say a market for food grains, and there is one seller who is selling a good quality food grain, and there is another seller or let us say all the other sellers are selling a bad quality food grain.

In that case, the seller who is selling the good quality food grain because he is the only one who is selling the good quality food grain, he would be able to increase the market prices.

But, if you have goods that are uniform, so every seller has the same goods of the same quality, then we would say that the market is competitive. If there is a variation in the quality of the goods that are being bought or sold in the market, then we will say that this is not a perfectly competitive market.

It is still a competitive market because you have many buyers and sellers, but it is not perfectly competitive because there could be certain buyers or sellers who value the quality of the goods. And in that case, they would be influencing the market prices. So, there is a slight influence on market prices. And so if the goods are not uniform, we will say that this is not a perfectly competitive market.

Then there are so many buyers and sellers that no single buyer or seller has any influence over

the market price; and all buyers and sellers are price takers. Now, what do we mean by price takers? It means that at the market price the buyers can buy all they want and the sellers can sell all they want.

What we are saying here is that there are many buyers and sellers. No buyer or seller has any influence over the market price. And once the market price has been determined by the behavior of so many buyers and sellers, then at the market price the seller should be able to sell as much of the good as he wants to, and the buyer should be able to buy as much of the good as he wants to. That is if the buyer has to purchase 10 units of something, then the 11th unit will also cost the same as the 10th unit, the 10th unit will also cost the same as the 11th unit and so on. So, once the market price has been fixed because of the actions of buyers and sellers, then everybody is a price taker, the buyer as well as the seller. The buyer will or can get the goods at the market price, and he can get as much amount of goods as he wants from the market because there are so many buyers and sellers.

And similarly the seller can sell as much amount of goods as he wants to sell at the market price. Then there is a perfect information transfer regarding prices. It means that if there is a market, there are so many different buyers and sellers; they are selling goods at different prices.

So, every buyer and every seller should know who is buying and selling at what price. What it means is that, suppose in the market you have 100 sellers, and say each of these sellers is selling the rice at the rate of 80 to 150 rupees a kg.

Now, if as a buyer, I enter into this market I should have perfect information about who is selling at what rate, so that I am able to buy at the lowest price. Similarly, if I am a seller I should know who is buying at what price, so that I can sell my products to that person who is buying at the largest price. And so when you have a perfect transfer of information, then there will be an equilibrium.

So, the seller will be selling the goods to the buyer who is paying the highest price, and the buyer is buying the goods from the seller who is selling at the lowest price. And this price which is the highest that the buyer is willing to pay, and the lowest that the seller is going to sell at this will be the market price. So, for a perfectly competitive market, there should be a perfect flow of information about the quality and the price of goods that are being bought and sold.

The market should have well defined property rights, which means that the only way in which you can buy or sell a good is through the market. Nobody can go to a seller and say snatch the goods because if the seller is having this idea that my goods can be stolen, then he or she will not be providing such a huge amount of goods to the market as he would have provided if there are perfect property rights.

Similarly, if there is a buyer, he should have confidence that there are property rights and his property rights are going to be respected. So, the working of the market requires well-defined property rights and this is a characteristic of a perfectly competitive market.

Then there should be a free entry and exit end to end from the market. What that means, is if there is a seller and the seller comes to know that say rice is being sold at 100 rupees a kg. Now, if this seller thinks that, oh, I can sell my rice at 99 rupees a kg, I can sell it for less than what the current market price is, then this seller should be able to enter into the market.

There should not be any restriction that only the sellers that are there in the market. They will be the only ones doing the same things. So, any seller should have the opportunity to freely enter the market.

Similarly, if there is a seller who finds out that I cannot sell below say 105 rupees, this seller should have the option of exiting the market. So, he can take his goods and move out of the market. Similarly, the buyer should be able to enter and exit freely. So, it means that there is no restriction on the number of buyers and sellers. And so anybody can enter the market or anybody can exit from the market. So, this is also another characteristic of a perfectly competitive market. Then it assumes that there is rationality both the buyers and the sellers are trying to maximize their utility. Now, we have seen before as well that economics assumes that everybody is a rational decision maker. And in the case of a perfectly competitive market, then we assume that everybody is a rational thinker, the buyers as well as the sellers. Now, both are acting to maximize their utility, they are trying to maximize their welfare.

And then there are zero transaction costs which means that if the market is large in size, I as a buyer should not have a thought that oh that seller is selling at a great distance, how am I going to go to that place. So, it says that there is zero transaction cost, there is no cost for a buyer to move from one seller to another seller. He does not have to pay money to go from one seller to another seller; he does not have to pay time to go from one seller to another seller.

And similarly the sellers also do not have any transaction cost. So, they can sell their goods to the buyer who is willing to pay the maximum amount of money. So, this means that there is no transaction cost.

Now, why are we making all these assumptions? This is because a perfectly competitive market is a theoretical concept. There is no market in the world that is perfectly competitive, because in any market there are transaction costs, in any market there are a fixed number of buyers and sellers. And in a number of markets, there is no free entry and exit. So, a number of these assumptions are violated.

The goods that are offered for sale, they may be different. There is a branding of goods in most of the markets. So, people may not consider one brand to be equivalent to another brand. Not everybody is a price taker. People try to negotiate, people try to haggle, people try to bargain.

We do not have a perfect information transfer regarding prices. So, it is possible that once we have bought your goods, you come to know that there is another seller who was selling at a lower rate. There is no perfect information transfer in the real world markets.

The property rights may or may not be well. So, well-defined free entry and exit into and from the market is not there in a number of cases. And also in a number of cases, people do not buy and sell rationally. A very good example is that in is that some people may try to buy from people who belong to their own community, or who belong to their own race, or people who are talking in the same talk.

Similarly, a seller might try to differentiate between different buyers. So, in these cases, the buyers and sellers are not taking a rational decision. In a number of cases, people are so overwhelmed by advertisements that they may buy a good which may be of an inferior quality or at a higher price just because they have been exposed to an advertisement.

Now, in a real world market these assumptions do not hold completely, which is why we are making this theoretical concept of a perfectly competitive market. And we will use this model of a perfectly competitive market to analyze what is going to be the ideal situation.

And from there, we can make a judgment about how good or bad the real situation is. So, we are talking about an ideal, perfectly competitive market. Now, in the market, there is a demand for products and there is a supply for products. So, we define quantity demanded as the amount of a good that buyers are willing and able to purchase. The quantity demanded is the amount of a good, how many units of the good are there that the buyers are willing to purchase and they are able to purchase.

Now, they should be both willing and able. It is not willing or able because there are certain buyers who want to buy a product, but they do not have money. So, in that case, their willingness does not count in the quantity that is demanded in the market.

Similarly, there could be buyers who are able to purchase the good, but they are not willing to purchase the good, say at this price. So, in that case, we will not include them in the quantity that is demanded of the good.

Then we define the law of demand. The law of demand is the claim that, other things being equal, the quantity demanded of a good falls when the price of the good rises. It is the claim that other things being equal. So, here again we are making an assumption that everything else being the same.

We are only changing one thing and that is the price of the goods; everything else remains the same, the quality of goods remains the same, the social structure that is there in the society remains the same, the level of advertisement remains the same, the transaction cost remains the same. If everything else remains the same, then if you change the price of a good what will happen to the quantity demanded?

So, here what we are saying is that suppose in a market, mangoes are available for say 30 rupees a kg. If the price goes up, if the price is down 40 rupees a kg, will people still be demanding the same amount of mangoes or will the demand change? So, the law of demand says that other things being equal the quantity demanded of a good falls or will reduce when the price of good rises. So, there is an inverse correlation. If the price increases, the quantity demanded falls.

And demand curve is a graph of this relationship between the price of a good at the quantity that is demanded. So, this is how a demand curve looks like. On the y-axis, we have the price of the good; on the x-axis, we have the quantity that is demanded in the good. And this green line shows us the demand curve. So, it is telling us that as the price increases, so when the price increases, we are moving on the y-axis from bottom to upwards.

If we take say two points - we take this point and we take this point, now at this point, so it is, draw these lines. So, what that law of demand tells us is that as the price increases, we are talking about these two prices. So, this is the price P_1 and here you have the price P_2 . Now, as the price has increased from P_1 to P_2 , what happens to the demand or let us say the quantity demanded.

At price P_1 , the quantity demanded was this much Q_1 ; and at price P_2 , the quantity that is demanded is Q_2 . Now, the law of demand says that as the price increases from P_1 to P_2 , the quantity demanded reduces from Q_1 to Q_2 . So, there is an inverse correlation. This graph goes from

top left to bottom right. So, this is the law of demand. Other things being equal the quantity demanded of a good falls when the price of good rises. This is the demand - the law of demand.

And we can also make out a demand schedule. A demand schedule is a table that shows the relationship between the price of a good and the quantity demanded. So, we are not making a graph, we are making the table. Then we will say that it is a demand schedule.

This is an example of a demand schedule. We are talking about the price of a cake and the number of cakes that are demanded by an individual. Now, suppose there is a market for cake, you go to this market, and you decide that the value that a cake is going to provide to you is equal to 80 rupees which means that the value of the cake and your rice is 80 rupees.

Will you be paying anything more than 80 rupees? The answer is no, because you are doing rational thinking. But if the same cake is available to you for say 30 rupees, in that case you will not just take one cake, probably you will have more than a cake because you are trying to maximize your utility. So, in this case, the buyer will think that the value of the cake is 80 rupees; the price of the cake is 30 rupees. So, let me have more and more of this cake.

But then the demand or the quantity that is demanded will not be infinite. Why, because every buyer has limited funds, and the money that the buyer has could be used to purchase say this cake or it could be used to purchase something else as well. Now, because of that the quantity that is demanded will not be infinite if the value of the cake is greater than the price, then there will be a particular limit. But here the cheaper that you can get the cake that has a higher value in your eyes the more and more quantity you will be deriving or you will be willing to purchase. So, this is the demand schedule of an individual.

And when we plot this demand schedule, we get a demand curve. So, this demand curve is telling us here again you have the price of the cake and the quantity that is demanded. And you see an inverse correlation. If the price is less, the quantity demanded is more; if the price is more, the quantity demanded is less.

Now, in the market and especially in the competitive market, there is not just one buyer there are several buyers. And the market demand schedule is the sum of the individual demand schedules. So, if we say that the price of the cake is here in this column and the number of cakes that are demanded by 2 individuals - individual A and B are given like this. So, at a price of 0 rupees, individual A is demanding 16 cakes, individual B is demanding 6 cakes. So, the market demand will be the sum of both of these, which is 22 cakes.

When the price increases to 10 rupees, for A the quantity demanded reduces from 16 to 14; for B, it reduces from 6 to 5. And the total quantity demanded is now 14 plus 5 is 19. If the price increases further to 20 rupees, the quantity demanded reduces further. And here the market demand is 12 plus 4 is 16. And so we can figure out the quantity that is demanded in the market by adding up the quantity demanded by different buyers that are there in the market.

That is to say if this is the price, and this is the number of cakes that are demanded. If this is the curve for A, this is the curve for B, then this is the market demand curve by adding A and B.

Now, when we talk about the demand curve, there can be shifts in the demand curve. And we say that when the curve shifts to the right, then there is an increase in the demand. And when the curve shifts to the left, there is a decrease in demand. Now, what does that mean?

If the demand has increased, it would mean that at any price let us say at price P, so at any price P, the quantity that is demanded has increased if there is an increase in demand. So, earlier the quantity that was demanded was this Q₀. The quantity that is demanded now is this Q₁. So, if there is an increase in demand, then more will be the quantity demanded at any price.

In place of this price, if we say shift to another price, if we talk about the price here, so if this is P, this is Q₀, and this is Q₁. So, the quantity that is demanded at this price also has increased. You take any price and when there is an increase in demand, the quantity demanded will increase. And we represent it on the curve as the curve shifts to the right.

On the other hand, in the case of a decrease in demand, the quantity demanded at any price reduces, which is to say that earlier the price was Q₀, and earlier the quantity that was demanded was Q₀. Now, the quantity demanded is Q₂, and Q₂ is less than Q₀. So, this is showing a decrease in the demand. So, the quantity demanded at any price reduces or the curve shifts to the left.

Now, it is important to remember here that there are two kinds of movements. One is the shift of the curve either to the right or to the left which is known as a shift in the demand curve. And the second thing is movement along the curve. So, if we talk about this green curve, if the price changes, then the quantity that is demanded also changes. And the price increases, so you can have a situation that you have, you have this point, and you have this point.

Now, in the case of this green curve, if we see that the price has increased, so we are moving from this point to this point, the quantity that is demanded decreases. So, the quantity demanded here is more, and the quantity demanded at this point is less. Now, this is known as a movement along the demand curve. But when the demand curve itself shifts when we say that there is a shift in the demand curve.

Now, what can cause such shifts? Things include changes in the income. So, if there is a normal good and you have an increased income, then you will demand or you will demand more quantity of the good. A normal good is defined as a good for which other things being equal and increase in income leads to an increase in demand such as ice cream. So, what we are saying here is that if your income is 10,000 rupees a month and you are demanding say 3 ice creams in a month. If your income increases, so in place of earning 10,000 rupees a month - you are now earning 30,000 rupees a month, then the number of ice creams that you will demand will also increase. In that case, we say that it is a normal good.

On the other hand, there could be certain goods that are known as inferior goods. An inferior good is defined as a good for which other things being equal, and increase in income leads to a decrease in demand such as coarse grains. So, what we are saying here is that when we were earning 10,000 rupees a month, suppose you were buying 30 kgs of coarse grains, say millets in a month.

Now, if your income increases in place of earning 10,000 rupees, you are now earning 50,000 rupees. Will you be eating more and more of these coarse grains or will you shift to finer grains? The answer is you will shift to finer grains. Probably, you will shift your food habits to incorporate more milk or more fruits or more meat. In that case the quantity of the coarse grains that you were demanding will go down. So, this is an inferior good, a good for which other things being

equal an increase in income leads to a decrease in demand such as coarse grains.

Changes in income will lead to changes in the quantity that is demanded at any price. Now, when we are talking about the normal good or the inferior good, we are only talking about changes in income which is leading to a change in the demand. Now, this change in the demand will be at any price.

Suppose earlier the ice cream was available at 10 rupees for an ice cream, you start earning more. So, you demand more ice cream at 10 rupees. Suppose, the price of the ice cream was 20 rupees, here again if you have an increased income you will ask for more ice cream. It does not matter what the price of the ice cream is.

So, other things being equal an increase in income, leads to an increased demand at any price, so this will shift the demand curve. So, if people have more income, the demand curve will shift towards the right. If people have a reduced income, the demand curve will shift towards the left for normal goods.

Other things that shift the demand curve is the price of the related goods in which case we talk about substitutes and compliments. Now, in the case of substitutes, it is two goods for which an increase in the price of one leads to an increase in the demand for the other such as rice and wheat. So, rice and wheat are substitutes, because they are both staple grains.

Now, if there is a family that eats rice as well as wheat, and if there is an increase in the price of rice - so rice increases from say 80 rupees a kg to 120 rupees of kg, and there is no change in the price of B. So, what would most people do? Most people would try to reduce their rice consumption, and would try to increase their wheat consumption because for the same amount of money, for the same income, you have to meet a good with the amount of grains that your family needs.

So, if the price of rice has increased, you will eat more wheat. If the price of rice decreases, in that case you will probably eat less wheat and eat more rice. So, the price of related goods may change the demand or the quantity that is demanded, that is there is no change in the price of wheat, but because the price of rice is changing, so that will lead to a shift in the demand curve.

Other goods are things that are known as complements. In the case of compliments, it is two goods for which an increase in the price of one leads to a decrease in the demand for another such as coffee powder and sugar. So, if there is an increase in the price of coffee powder, now coffee powder and sugar are used together when you make coffee.

So, if there is an increase in the price of coffee powder, so in that case your coffee becomes more expensive, and you will try to reduce the amount of coffee that you are drinking. And probably shift to something else such as tea or such as cola. Now, in this case, the price of coffee powder has increased, and so you have shifted to say drinking cold drinks.

Now, in the earlier case, you were having more amount of coffee and for that you were demanding more amount of sugar. Now that you are drinking less coffee, you will demand less quantity of sugar. So, an increase in the price of coffee is leading to a decrease in the demand for sugar because coffee powder and sugar are complements. A change in the price of related goods will lead to a shift in the demand curve.

Then taste, such as an increased demand for ice cream with the onset of summer, because with the onset of summer more and more people want to have ice creams. So, nothing else is chang-

ing, but the demand for ice cream will increase in the summer season. So, the curve will shift towards the right.

Other things include expectations. If taxes on petrol are to rise from next month, the demand in this month will increase because people expect that in the next month because of increased taxes we will have to pay more for petrol. So, why not fill our tanks to the brim. So, the demand in this month, in the current month, will increase if people are expecting the prices to go up.

Similarly, if you expect that the price of any product is going to increase in the future, you will try to have or hold more and more of that product. If the price is going to reduce in future, then probably you will cut down on the amount of that good that you are buying now.

For instance, when the price of real estate is going down, less and less people want to buy a home, because they think that if we do not buy the home now if we wait for a few more months, we will be able to get this home at a cheaper rate at a lower price. So, expectations can also lead to changes in the demand curve, and also the number of buyers.

So, the more the number of buyers in a market, the more is the demand. And this especially holds true when there is an economy that is opening up. So, earlier in our country when our market was not an open market then only the buyers in India were able to purchase the goods that were being produced. But these days our goods have a market everywhere they have a demand everywhere.

Even a person in the United States might want to purchase something that was manufactured in India. So, because the number of buyers have gone up, that will lead to a shift in the demand curve because more and more quantity is being demanded because there are more and more buyers at any price. So, these are shifts in the demand curve.

Now, similarly we can talk about supply. The quantity supplied is the amount of a good that sellers are willing and able to sell. The sellers should be willing to sell at that price, and the sellers should be able to sell that is they must be having the good or they must be in a position to make the good.

Law of supply is the claim that other things being equal, the quantity supplied of a good rises when the price of the good rises. Now, suppose there is a seller of mangoes, if the price of mango increases, then this seller will be ready to supply more quantity of mango because he wants to maximize his profit.

When the price increases, he will supply more mangos; when the price decreases, then probably he will supply less mangos. This is the law of supply, other things being equal, the quantity supplied of a good increases or rises when the price of good rises. And we can represent it through a supply curve which is a graph of the relationship between the price of a good and the quantity that is supplied of the good.

This is the supply curve. When the price increases, so you are moving from say this point to this point; so when the price increases the quantity that is supplied also increases. So, this is the law of supply. We can represent the law of supply through the supply curve or through the supply schedule. A supply schedule is a table that shows the relationship between the price of a good and the quantity that is supplied.

This is a supply schedule, the price of a cake and the number of cakes that are supplied. If the

price of a cake is 0 rupees, then probably no seller will be supplying any cake because it will only result in a loss because there is a cost involved in making the cake. If the price of 1 cake is 10 rupees, then again if the cost of manufacturing is greater than or equal to 10 rupees, then no seller will be able to or able and willing to supply the cake.

If the price increases to 20 rupees, probably, a seller is ready to supply 2 cakes. If the price increases further to 30 rupees, the seller will supply more cakes because now the seller is getting an incentive to increase his profit by making more and more cakes. If the price of 1 cake increases to 80 rupees, the seller will be ready to supply 14 cakes.

Now, here again if the cost of making the cake is 10 rupees, then at a cost at a price that is greater than the cost of manufacturing say at 80 rupees, the number of cakes that are supplied by the seller will not be infinite because there is an opportunity cost involved. So, even though by supplying more and more cakes, the seller can maximize his profit. So, the number of cakes that he supplies at any price will not go to infinity.

And we can use this supply schedule to make a supply curve. So, here it is showing that as the price of the cake increases, the number of cakes that are supplied also increases. And in a market as we have seen before, if there are multiple suppliers, then the total supply is equal to the supply of cakes by each seller. So, at 0 rupees, seller 1 is going to supply 0 cakes; seller 2 is going to supply 0 cakes.

So, the total market supply is 0. At 10 rupees, again 0, 0, that is 0. At 20 rupees, individual A or seller A is ready to supply 2 cakes. Individual B thinks that I still cannot supply anything. So, here the market supply is 2 plus 0 is 2. At thirty rupees, it is 4 plus 1 which is 5. At 40 rupees, it is 6 plus 2 is 8.

Here we are observing that at any price if you take the sum of the cakes that are being supplied by each seller, you will get the amount of cake that is being supplied to the market.

Or we can also say that if the red curve is showing the supply curve of seller A, the blue curve is showing the supply curve of seller B. Then this green curve which is the sum of A and B is telling us the supply curve of the market.

And as before we can talk about movement along the supply curve and shift in the supply curve. So, in this case, we are moving along the supply curve. But if there is an increase in supply, it would mean that at any price P, the quantity that is supplied would increase.

So, we will show it by means of a curve that has shifted to the right. The blue curve is showing an increased supply as compared to the green curve. Similarly, if there is a decrease in supply, it will mean that less quantity is supplied at any price. And this would be represented by a curve shifting to the left. So, this is a shift in the supply curve.

Now, what can cause such shifts? We can have changes in the input prices. So, in the making of a cake, you require flour, you require sugar. And if the price of flour changes or if the price of sugar changes, then each seller will be more or less able to supply the cakes to the market at any given price point. That would lead to a shift in the supply curve. Because earlier when the prices were low, one seller was ready to supply say 2 cakes for 10 rupees.

Now, the price of sugar has gone up, the price of flour has gone up, and it is now taking him 12 rupees to manufacture a cake. So, in that case the number of cakes that the seller is willing to

supply or is able to supply to the market at 10 rupees will become 0. So, in place of supplying 2 cakes, he is now supplying 0 cakes.

It is telling us that at this price point of 10 rupees, the number of cakes that are being supplied to the market have gone down. And so we will see a shift to the left in the case of the supply curve. Similarly, if the cost of inputs goes down that is if it has become cheaper to purchase flour and to purchase sugar, then probably each seller will be able to supply more of the cake at any given price point, and so we will see a shift in the supply curve towards the right which will show us an increase in the supply. So, the shifts in the supply curve can be caused by changes in the input prices or because of changes in technology which also changes the cost of producing a cake.

Also changes in expectations can lead to changes in the supply curve. So, if the price of sugar is expected to rise from next month, the seller may choose to stock the sugar and not supply it. So, it is telling us that similar to the case of an increased taxation in petrol - if next month the price of petrol is going to go up, then each person would want to stock the petrol and so the demand for petrol will go up.

Now, what will happen to the supply? If you think about petrol from the seller's point of view the seller would say that ok next month the price of petrol is going to rise, so and I have this stock of petrol, why should I sell it for a lower price, why should I not hold this petrol and sell it in the next month. So, because of an expectation of change in price, there can be a shift in the supply.

Also the number of sellers - so, if more sellers are available in a market, the supply curve will shift towards the right because now more and more quantities of goods will be available to be sold in the market because there are more sellers. So, these are the reasons for shifts in the supply curve.

Now, in a market, these demand and supply curves will meet at a point. They will intersect each other. So, if we show that this is the demand curve, this is the supply curve, there will be a certain point at which both of these curves will intersect each other.

And when that happens we will say that there is an equilibrium. Equilibrium is the situation in which the market price has reached the level at which the quantity supplied equals the quantity demanded. It is the situation at which the market price has reached the level which means that at this price the quantity that is supplied, and the quantity that is demanded is one and the same.

If we look at any other price, if we say look at this price, so at this price the quantity that is demanded is this much and the quantity that is supplied is this much. So, there is a difference between the quantity that is demanded and the quantity that is supplied.

If the price goes down, so in that case the quantity that is demanded will increase, because remember when the prices go down the quantity that is demanded goes up, whereas, because the price has gone down the quantity that is supplied will also go down because of the law of supply. So, now you have less of a difference between the quantity that is demanded and the quantity that is supplied, but still there is a difference.

But when the price goes down and reaches this point, so here the quantity that is demanded is this, and the quantity that is supplied is also this. So, now, this is showing us an equilibrium. So, an equilibrium is the state where the price is such that the quantity that is demanded is equal to the quantity that is supplied.

If the price goes down even further, so if the price is less the quantity that is demanded will increase, and the quantity that is supplied will decrease. So, here again we will see that there is a disequilibrium. There is a difference between the quantity that is demanded which is the point where this curve of price intersects with the demand curve - this point. This is the quantity that is demanded.

And this is the quantity that is supplied to the point where this price curve intersects with the supply curve. So, there is a difference between the quantity that is demanded and the quantity that is supplied.

But at this price point this quantity that is demanded is the point where this line the the price line intersects the demand curve which is this point. And the quantity that is supplied is the point where the price curve intersects with the supply curve which is also here because the demand and supply curves are intersecting each other. So, this is known as equilibrium, a situation in which the market price has reached the level at which the quantity that is supplied is equal to the quantity that is demanded.

Now, at this price, we will say that it is the equilibrium price, the price that balances the quantity supplied and the quantity demanded. And the quantity that is demanded or supplied at this price point will be known as the equilibrium quantity. So, equilibrium quantity is the quantity supplied and the quantity demanded at the equilibrium price. And both of these are equal to the same.

And this brings us to the law of supply and demand. The claim that the price of any good exists to bring the quantity supplied and the quantity demanded for that good into balance. So, what is the law of supply and demand? It is the claim that the price of any good adjusts. So, when we say that it is adjusting, we mean that this price goes up and down, but then it ultimately reaches to this point.

So, it adjusts to bring the quantity supplied and the quantity demanded for that good into balance. And at that price known as the equilibrium price, the quantity demanded is equal to the quantity supplied is equal to the equilibrium quantity.

Now, how do markets respond to changes in the demand and supply? So, there is an increase in demand, what happens? Now, what we are saying here is that in place of say a market with just 100 buyers, now we have 1000 buyers in the market and because the number of buyers has gone up.

So, the quantity that is demanded has also increased at any particular price point. So, this can be represented by a shift in the demand curve. Now, the supply remains the same, but the demand has changed. So, the demand curve has shifted to the right.

Which is what we can represent like this. So, earlier the green line - this one is showing us the demand curve, this is the supply curve. Now, because of an increase in demand, there is a shift in the demand curve. So, the demand curve from here shifts to this red line. An increase in demand is shown by the demand curve shifting to the right.

Now, what happens? Earlier the demand and the supply curve were intersecting at this point. Now, the demand and the supply curve are intersecting at this point. So, this is the earlier equilibrium, and this is the new equilibrium because of the change in demand.

What happens to the price and what happens to the quantity that is supplied? Earlier the price

was this one. So, this is the earlier equilibrium price. Now, because of a shift in the demand curve, the new equilibrium price is this much. So, the price has gone up which is expected because now more and more people are demanding the same goods. So, more is the demand, more is the price. Also earlier the quantity that was supplied was this much. Now, the quantity that is demanded and supplied is this much. So, there is an increase in the quantity that is demanded or supplied.

An increase in demand with no change in the supply will increase the price and it will increase the quantity that is demanded or supplied. So, an increased demand leads to more price and more sales.

What happens because of a decrease in supply? So, a decrease in supply will be shown by a supply curve that is shifting to the left. So, earlier this was the demand curve, and this was the supply curve. And this was the earlier equilibrium. Now, there is a decreased supply. So, the supply curve has shifted to the left. And we will now have this red color supply curve.

The demand has remained the same. And this point is showing us the new equilibrium. Now, what are the impacts in the market? Earlier the equilibrium price was this much, the new equilibrium price is this much. So, the price has gone up because there is a decreased supply in the market. So, decrease in supply will lead to more price.

What happens to the quantity that is demanded or supplied? Earlier the quantity demanded or supplied was this much, now it has reached this point. So, there is a decrease in the quantity that is demanded or supplied. So, a decrease in supply will lead to an increase in price, but a decrease in the quantity that is demanded or supplied means more price and less sales.

Now, what happens when there is an increased demand and there is a decreased supply? Now, in this case, we are saying that there is an increased demand plus a decreased supply. Now, an increase in demand leads to more price, a decreased supply leads to more price.

When both of these are acting together, we will have more price. Any increased demand led to more sales and decreased demand led to less sales. So, when both of these are acting together, then we may have more sales or less sales or the same sale.

Let us look at these. So, earlier the demand curve was this green line the supply curve was this green line. And this was the earlier equilibrium. Now, there is an increase in demand. So, the demand curve has shifted from here to here. So, the demand curve has shifted to the right, because there is an increased demand. The supply has reduced, and so the supply curve from this has shifted to this. So, there is a decrease in supply, and this is leading to this new equilibrium.

In this case, the earlier equilibrium price was this, the new equilibrium price was this. So, as was expected the prices increased, and in this case the earlier equilibrium quantity demanded or supplied was this, the new quantity is this. So, there is an increase in the quantity that is demanded or supplied, but it is also possible that when you have an increase in demand.

In this scenario, we are seeing that the main curve, the green demand curve, has shifted to the right. The green supply curve has shifted to the left. And in this case, the earlier equilibrium was here, the new equilibrium is here. Earlier equilibrium price was this; the new equilibrium price is this.

Here again the price or the equilibrium price has gone up, but the earlier quantity demanded was

this, the new quantity demanded is this. So, there is a decrease in the quantity that is demanding the supply of goods. So, it is possible in the case of an increased demand and a decreased supply at the same time. It is possible that the sales may increase or the sales may decrease, but in any case the price will go up.

We had seen in the 10 principles of economics that markets are usually a good way to organize economic activity. And in this case, we are observing that a very big benefit of a market is that it reaches into an equilibrium by itself. Now, in the case of a free market, in the case of a competitive market, there is no requirement of a government to state that this will be the price of mangoes, this will be the price of rice, this will be the price of dhal and so on.

The market will reach an equilibrium by itself through the working of the law of demand and supply. So, markets are a good way of organizing economic activity. And now we are analyzing how the markets work by using a theoretical formulation.

That is all for today. Thank you for your attention. Jai Hind!

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Module 6
Markets: Places where Economics works
Lecture 2
Elasticity

Namaste! We carry forward our discussion on Markets. And in this lecture, we will have a look at elasticity. So, before we begin let us recap what we had seen in the previous lecture.

We saw that there is a market equilibrium which is defined by the point where the demand and the supply curves meet each other or intersect each other. The demand curve as we had seen it slopes downwards which means that if there is an increase in price from this point to say this point, if there is an increase in price, the quantity that is demanded goes down. On the other hand, the supply curve is sloping upwards because if there is an increase in price from this point to this point, then the quantity that is supplied increases.

And when the demand and the supply curves intersect each other, we reach this point. The price that is defined by this point of intersection is known as the equilibrium price. And this is the price at which the quantity that is demanded is equal to the quantity that is supplied which is the equilibrium quantity. And we also explored what happens when there is a change in the demand for change in the supply.

A change in demand is represented by a shift in the demand curve. So, if there is an increase in the demand which is shown by this demand curve that is shifting towards the right; and a decrease in demand is shown by the demand curve that is shifting towards the left. Now, if we consider an increase in demand, so here the earlier demand curve was this, the new demand curve is this.

If there is an increase in demand, then what happens to the price and to the quantity that is demanded or supplied? What happens to the equilibrium? As we can observe here, the earlier equilibrium is at this point, the new equilibrium is at this point. Now, at the old equilibrium, this way this was the equilibrium price; at the new equilibrium this is the equilibrium price, which means that the equilibrium price increases if there is an increase in demand.

Similarly, earlier the quantity that was demanded at the equilibrium was this; now with an increase in demand the quantity that is demanded is this. So, there is an increase. So, if there is an increased demand, then we have observed that there is an increase in the equilibrium price and an increase in the equilibrium quantity that is demanded or supplied in the market. So, this is an increase in demand. In the case of a decrease in demand, we will have this curve which is towards the left side. So, we will have a curve like this. And in that case, we will find that the equi-

librium price reduces and the equilibrium quantity also reduces.

What happens when there is a change in the supply? Now, an increase in supply is shown by the supply curve that will shift towards the right, and a decrease in supply is shown by the supply curve that shifts towards the left. Now, in this case, this is the original supply curve, and this is the new supply curve. So, the supply curve has shifted to the left which means that we are now talking about a decreased supply.

Now, there is no change in the demand curve. So, the earlier equilibrium was at this point; the new equilibrium is at this point. Now, earlier the price at equilibrium was this; the new price at equilibrium is this. So, what we are observing here is that if there is a decrease in supply that leads to an increase in the equilibrium price. So, less is the quantity that is being supplied in the market, so there will be more price at which people will have to buy this product.

What happens to the equilibrium quantity, will earlier the equilibrium quantity was this; the new equilibrium quantity is this. And as we can see there is a decrease in the quantity that is demanded or supplied. So, with a decreased supply, there is an increase in the price; and a decrease in the net quantity that is demanded or supplied in this market.

Now, when both of these processes happen together, that is, there is an increase in demand and a decrease in supply, then we observe that the price will increase, but the quantity that is demanded or supplied may either increase or decrease. So, we saw that if the situation is like this, so this is the earlier demand curve, this is the new demand curve which is showing that there is an increase in the demand. This was the earlier supply curve. This is the new supply curve which is telling us that there is a decrease in supply.

So, we are looking at an increased demand and a decreased supply. The earlier equilibrium was at this point, the new equilibrium is at this point. So, where there two red curves are intersecting with the new equilibrium, where there two green curves are intersecting is the old equilibrium.

This was the old equilibrium price; this is the new equilibrium price. And so we are observing here that the price has increased, the equilibrium price has increased which was expected because in the case of an increased demand the price increases, in the case of a decreased supply the price increases. And so when both are acting together, the price will increase.

But what is happening to the quantity that is demanded or supplied? Well, the earlier quantity was represented by this point. This is the quantity that was demanded or supplied earlier. The new equilibrium is at this point. The quantity that is demanded or supplied nowadays has this point.

In this case, what we are observing is that the new quantity that is demanded or supplied is greater than the earlier quantity that was demanded or supplied. So, what we are observing here is that with an increase in demand and a decrease in supply, there is an increase in the quantity that is demanded or supplied.

But, this is not always the case because we also saw this market equilibrium in which case the earlier equilibrium was here. This was the old demand curve; this is the new demand curve. So, here again we are looking at an increase in demand. This was the old supply curve.

This is the new supply curve. So, here the supply curve has shifted to the left. So, we are looking at a decreased supply. So, as in this slide, we have an increase in demand and decreased supply

and the same thing here as well, an increase in the demand and a decrease in the supply. The question is what is happening to the equilibrium in this case? The earlier equilibrium was here whether the green curves are intersecting. This was the equilibrium price, and this was the equilibrium quantity. The new equilibrium is at this point where the red curves intersect. And this is the new price, and this is the quantity that is demanded or supplied.

Here again we are observing that the earlier equilibrium price goes here, the new equilibrium price is here which means that there is an increase in the equilibrium price. However, the earlier quantity demanded was this much, the new quantity demanded is this much. So, there is a decrease in the quantity that is demanded or supplied in this market.

Earlier we saw that there is an increase in the price, and there is an increase in the quantity that is demanded or supplied. Whereas, here there is an increase in price, but there is a decrease in the quantity that is demanded or supplied. So, what we are observing here is that in the case of an increased demand and decreased supply, there will always be an increase in price, but the equilibrium quantity that is demanded or supplied that may increase or that may decrease.

Now, the question here is in what circumstances would these equilibrium quantities increase, and in what circumstances would they decrease? What are the factors that govern that? And that brings us to the topic of elasticity.

The amount of these shifts depends on the shapes of the curves, and that tells us about the elasticity of demand and supply.

We define elasticity as a measure of how much buyers and sellers respond to changes in the market conditions. So, we are trying to measure the response of buyers and sellers, and we are trying to measure how much this response changes the extent of the state.

So, we are trying to measure the direction of change and we are trying to measure the magnitude of the change, and these changes in response to changes in the market conditions. So, whenever there is a change in the market conditions, does this demand and supply increase or decrease, and in which direction, and by how much is the question?

That is if we look at the demand curve, the demand curves are always sloping downwards. But then does it look like this, does it look like this, or does it more or less flat? So, these are all different demand curves, but they have a different angle of slope. And what we are trying to understand now is how this angle of slope determines the market outcome or influences the market outcome.

Similarly, if we look at the supply curves, the supply curves are always moving upwards. But do they slope upwards in a nearly vertical manner, or do they slope upward in a very flat manner, or is it somewhere in between? So, there are all these different kinds of supply curves, the question is how does the shape or the slope of the demand and supply curve influence how the market behaves.

So, elasticity is a measure of how much buyers and sellers respond to changes in the market conditions. Also we can define it as a measure of the responsiveness of quantity demanded or quantity supplied to a change in one of its determinants.

Now, in the earlier definition, we said how much buyers and sellers respond. Now, this response is seen in terms of how much is the quantity demanded or supplied. So, if there is a response

from the buyers, then we will see a change in the quantity demanded. If there is a response in the sellers, we will see a change in the quantity that is supplied.

And we are trying to measure what is this response in terms of changes in the market conditions or in terms of changes in the determinants of the quantity demanded or supply. So, this is elasticity.

So, the question is that we are trying to measure what is the response of the buyers and the sellers, but then is there a way in which we can quantify this? Because remember we are trying to measure the change in the direction and we are trying to measure the change in the magnitude.

Now, if we wanted to do that, we would require certain formulas. And this is one such formula. The demand and supply can change in response to changes in their determinants. So, what are these determinants? One determinant is price. So, what is the change in the demand curve in response to the price or changes in the price of products?

So, for instance, if you were buying rice at 100 rupees a kg, if the price increases to 120 rupees a kg, would you demand more of rice, would you demand less of rice? And if you do make a change in the demand, what would be the magnitude of the stream? That is if earlier you were buying 30 kgs of rice, and if because of an increase in price you are reducing your consumption, will it reduce from 30 to say 29 kgs? How will it reduce from 30 kgs to 10 kgs? What is the magnitude?

So, we are looking at what is the direction of change, is it increasing, or is it decreasing, and the magnitude by how much is it increasing or decreasing. So, the price elasticity of demand can be defined as a measure of how much the quantity demanded of a good responds to a change in the price of that one. To remember it easily, you can always remember the example of how much the quantity demanded of rice responds to change in the price of rice. And it is computed as the percentage change in quantity demanded divided by the percentage change in the price.

So, we are saying that there is a change in price and there is a change in the quantity demanded. The price elasticity of demand is the percentage change in the quantity demanded, that is whether you have decreased your consumption if you say decrease it from 30 kgs to 27 kgs.

There is a 10 percent decrease because you are reducing it by 3 kg: 10 percent of 30 kg. If you reduce it from 30 kgs to 15 kgs, then there is a 50 percent change. So, this is what is there in the numerator, percentage change is the quantity that is demanded divided by percentage change in price.

If the price has increased from 100 rupees a kg to 110 rupees a kg, there is a 10 percent increase. If the price increases from 100 rupees a kg to 125 rupees a kg, there is a 25 percent change in price. So, in the case of class price elasticity of demand, we are measuring the percentage change in quantity demanded divided by the percentage change in price.

Now, this figure price elasticity of demand can be 0. Why 0? If there is no change in the quantity that is demanded, which means that when the rice was available at 100 rupees a kg, we were buying 30 kgs of rice. But when the price increases to 110 rupees a kg, you are still buying 30 kgs of rice because rice is the staple food.

In such a scenario, we will find that there is a certain change in the price by 10 percent, but there is no change in the quantity demanded. So, the change is 0 percent. So, in that case, the price

elasticity of demand will be 0.

Now, in cases where the price elasticity is 0 or close to 0, we said that the demand is inelastic which means that you are not changing your demand on the basis of the changes in the price. So, the price elasticity of demand when it is close to 0, we say that it is an inelastic demand.

On the other hand, it is also possible that with a small change in price new for instance make a big change in the quantity that is demanded. A good example is suppose you are equally fond of eating chocolate ice cream, and vanilla ice cream. Now, if the price of vanilla ice cream increases, what you do is that even if there is a small increase earlier you were having a cone of both of these ice creams for say 20 rupees. Now, currently the price of chocolate ice cream has remained at 20 rupees, but the price of vanilla ice cream has increased from say 20 rupees to 25 rupees.

Now, what do you do? Now, your response could be that because the price of vanilla ice cream has increased, but I am equally fond of chocolate ice cream as well. So, let me now forgo the the vanilla ice cream and let me have more and more of the chocolate ice cream.

In that case even though the price has increased only from 20 rupees to 25 rupees, you will spend most of your money purchasing the chocolate ice cream and you will purchase a very less amount of the vanilla ice cream. It is also possible that in the case of eating 20 vanilla ice creams, now you are eating just 2 or 3 vanilla ice creams or you are not eating any vanilla ice cream.

When that happens, there is a small change in price, but there is a big change in the quantity that is demanded. When that happens, we will have a price elasticity of demand which is very large because the numerator is large, the denominator is small. And in that case, we will say that the price elasticity is very much. In a theoretical sense, we can say that the price elasticity is so large that it can even tend towards infinity.

So, an elastic demand will tell us that there is a big change in the quantity that is demanded even though the change in the price is very small. And inelastic demand would say that even if the price increases by a lot, there is hardly any change in the quantity that is demanded.

And we can see these in this price elasticity or p of demand in the shape of the demand curves. Now, this is a perfectly inelastic demand curve that is the elasticity is equal to 0. Why, because even though you have a big change in the price, there is hardly any change in the quantity demanded.

So, the percentage change in quantity demanded is 0, the percentage change in the price is very large and so the price elasticity of demand in this case, is the percentage change in quantity demanded is 0 divided by percentage change in price which is the very large value. So, in total it becomes percent price elasticity of demand is equal to 0 which is what we are seeing here elasticity is equal to 0. So, this is a perfectly inelastic term.

On the other hand, this is a perfectly elastic curve which means that if there is a small change in the price, there is a large change in the quantity that is demanded. That is the numerator here is very large because there is a big change in the quantity that is demanded, then the denominator here is very small because there is hardly any change in the price and so the price elasticity of demand in this case is close to infinity.

And we say that this is a perfectly elastic demand curve. We can also have a unit elastic demand curve in which case the elasticity is equal to 1. So, the percentage change in price and the percentage change in the quantity demanded are equal.

Now, an easy way to remember the shapes of these curves is by remembering the word inelastic. Now, the word inelastic begins with an I. And we can see that in the case of an inelastic demand curve it looks like the alphabet I. So, it is vertical. So, when you have a vertical demand curve, then it is inelastic. When you have a horizontal demand curve, then it is elastic now.

When you have a demand curve like this, it is not completely vertical, but it is more towards an inelastic demand shape than an elastic demand shape. We will call that this is still an inelastic demand curve, but it is less elastic than see this inelastic demand curve. This demand curve we will say that this is more elastic than this, but it is less elastic than the perfectly elastic demand curve which is completely horizontal. So, these are different price elasticities of demand.

Now, what determines whether this demand curve will be vertical or horizontal or something in between? What are the determinants of the price elasticity of demand? The first determinant is whether you have close substitutes that are available. If close substitutes are available, the demand will be more elastic, which means that when we say that we will have a more elastic demand, it would mean that there will be a big change in the quantity that is demanded if there is a small change in the price.

Now, why would that happen? Because, if you have things such as rice and wheat, now rice and wheat are close substitutes, so, in case the price of rice increases, then you can reduce your quantity of rice demanded, and you can shift more towards wheat. So, in this case, if you have a closed substitute that is available, whenever there is a change in price, you can reduce the quantity of that particular product and you can shift to its substitute.

Another example is say different flavours of ice creams. They are close substitutes. So, if the price of one flavour increases, you will shift to another flavour, or the option of having different flavours of cold drinks. Now, all of these are close substitutes. And so if you have a close substitute, then the demand becomes more elastic because you have the option of shifting to the substitute if the price increases or decreases.

Another determinant is whether the item is a luxury or whether it is a necessity. Now, luxuries have a greater elasticity of demand than necessities. Because, in the case of necessities, you have to have that item because it is necessary for your survival. So, if you talk about a thing such as food, now food will have a pretty inelastic demand curve because even if the price increases, people need to have access to sufficient quantities of food.

But if there is a thing such as a luxury item, say ornaments, now if the price of gold increases, it is possible that people will decrease the amount of money that they will put into gold. They will in turn say start to purchase stocks or they will start to purchase land because in this case gold is not a necessity, it is a luxury. Now, in the case of necessities, the demand curve is very inelastic. In the case of luxuries, the demand curve is very elastic because here again you can shift to something else if you have the option.

Then it also depends on how you define the market. Because if we look at food, food has an inelastic demand, because people need to have access to food whatever be the price. So, even if the

price increases, people will have to eat roughly the same quantity of food and so the demand for food is inelastic.

But if you look at the market in a very narrow manner, then we will see that different things have large elasticities such as chocolate, ice cream has an elastic demand. Why? Because, if the price of chocolate, ice cream increases, then people will reduce their consumption.

But when we look at food in total then even if the price increases or decreases the quantity that is demanded will remain the same. So, the definition of the market can play a role in determining whether the price elasticity of demand is elastic or inelastic. And the more generalized way you look at the market the demand will be very inelastic. But if you look at the market in terms of very specialized products then you will have an elastic demand curve.

This is also true because when you look at specialized items, then there are a number of substitutes that are available. And because of the presence of close substitutes the demand curve will become more and more elastic.

Another determinant of price elasticity is the time horizon which is are you looking at things in a short term or in a long term. Now, elasticity increases over longer time horizons as more substitutes become available. Now, here again it is the availability of the close substitutes that we are looking at. If you have a close substitute, then probably that the demand curve will be more elastic.

The question is how soon will you have these close substitutes? In a short term, it is possible that you will not have access to the closer substitute because they either do not exist or because they are not available in your market. But on a longer time horizon, people will come up with new inventions or people will bring closer substitutes from other markets because the price of something has changed in your market.

So, elasticity increases over longer time horizons as more substitutes become available. Example, when the price of petrol increases, the demand is pretty inelastic in the short term. Why? You do not have an alternative for petrol, because if you have a vehicle which runs on petrol and the price of petrol has increased, but even then you have to travel from point A to point B, so you will have to purchase the same quantity of petrol, no matter what the price is.

But on a longer time horizon, it is possible that you shift from your vehicle to some other vehicle, probably you purchase an electric vehicle in which case because the price of petrol has increased you will now start to travel more and more in the electric vehicle. And so you will reduce your consumption of petrol.

Now, this is generally not very feasible in the short term, but in the longer term we can make changes to our lifestyle, we can make changes to the products that we are using. So, the demand is pretty inelastic in the short term, but it is very elastic in the long term due to greater availability of more fuel efficient cars or electric cars.

So, in the long term, you make changes to the items that you are using. And you make changes in a way that you have access to some of the other substitutes. Probably, you will shift from a petrol car to a diesel car or a CNG car or an electric vehicle, or maybe to a more fuel efficient vehicle, so that you are able to reduce the quantity of petrol that you are demanding. So, the important thing to remember here is that in the short term the demand curves are generally inelastic, but in

the longer or time horizons the demand curves become pretty elastic.

Now, similar to the price elasticity of demand, we also have the income elasticity of demand. The income elasticity of demand asks the question that if your income increases what happens to the demand for a certain good or service that is it is a measure of how much the quantity demanded of a good response to a change in the consumer's income.

If the income increases or decreases, does it lead to a change in the quantity demanded? And it is computed as the percentage change in quantity demanded divided by the percentage change in income. So, very similar to what we saw here, in the case of price elasticity, it was the percentage change in quantity demanded divided by the percentage change in price.

Here we have percentage change in quantity demanded divided by percentage change in income. Now, there are certain products for which the income elasticity is very close to 0 things such as food grains. So, for instance, if your income doubles, you are not going to consume double the amount of food grains. You will probably consume only that much amount of food grains that you are having before. So, in things such as food grains, the income elasticity is very less.

On the other hand, for luxury goods, the income elasticity is pretty high because if you have more income, then probably you would want to have finer clothes or you would want to have more ice creams, or you would want to go out to watch movies even more.

For things such as going out for a movie, the product here is the movie ticket. And when the income increases, the demand for the movie ticket increases; when income increases, the demand for ice creams increases; when income increases, the demand for clothes would increase. So, there are certain products for which the income elasticity is very high. On the other hand for things such as necessities the income elasticity is pretty low.

Similarly, we also have the cross price elasticity of demand. Now, in the case of cross price elasticity, it is a measure of how much the quantity demanded of one good responds to a change in the price of another good, computed as the percentage change in the quantity demanded of the first good divided by the percentage change in the price of the second good.

Now, in the case of cross price elasticity of demand, the question that we are asking is if the price of one good increases, what is the impact on this increase in price on the demand for another good? So, for instance, if the price of rice increases, will it lead to a change in the demand for wheat? Because when the price of rice increases people would probably go for consuming less quantity of rice, and they will want to have more quantity of wheat because rice and wheat are substitutes.

In this case, the question being asked is if there is say a 10 percent increase in the price of rice, what is the percentage change in the demand for wheat? Or, similarly, if the price of chocolate ice cream increases, is there a difference in the demand for say pineapple ice creams?

So, cross price elasticity of demand is the percentage change in quantity demanded of good 1 divided by percentage change in the price of good 2. So, in the price of good 2 changes what is the impact on the demand for good 1 is what we are asking in the cross price elasticity of milk

Now, similar to the elasticity of demand, we also have the elasticity of supply. Now, price elasticity of supply similar to what we had in the case of price elasticity of demand is a measure of how much the quantity supplied of a good response to a change in the price of that good, com-

puted again as the percentage change in the quantity supplied divided by the percentage change in price.

So, if there is a change in the price of a good, does that impact the quantity that is being supplied in the market? Now, for a number of goods, there will be a change because when the price of mangoes increases people would want to supply more mangoes to the market. Probably they would even pluck out those mangoes that are not ripe because of an increase in price. They want to maximize their welfare, they want to maximize the profit that they have. If the price of food grains increase, then the sellers would even take out the food grains that they have stockpiled, and they would bring that out to the market because of an increased price they would think that ok let us have a greater amount of profit.

Now, the price elasticity of supply is asking the same question. If there is a percentage change in price, what is the percentage change in the quantity that is supplied of a good? And different items may have different price elasticities of supply.

We can have a perfectly inelastic supply curve such as this. Now, in this case, even though there is a big change in the price, there is hardly any difference in the quantity that is being supplied. So, even at this price, the quantity supplied is this much; and even at a higher price within this, the quantity supplied is the same.

So, here again we are having the same supply. So, this sort of a curve is a perfectly inelastic curve. And we will say that the elasticity in this case is 0 because even though we have a big difference in price. So, here the denominator is a big term. There is virtually no change in the quantity that is applied, that is the numerator is 0. So, this is an example of a perfectly inelastic supply.

Now, in the case of a perfectly elastic supply, if you have a very minuscule change in price, you will have a big difference in the quantity that is supplied that is in the case of an elastic supply when the percentage change in price is close to 0 that is the denominator is close to 0, the numerator is a very very big value. So, this is a perfectly elastic supply curve. So, elasticity is close to infinity.

Now, as we have seen in the case of the demand curves, when there is an inelastic supply, we can remember it by remembering that the word inelastic begins with the letter I, and I is roughly vertical. So, if you have a curve that is roughly vertical, then it is in inelastic supply.

If you have a curve that is roughly horizontal, then it is an elastic supply. Then we can have different levels of elasticity. So, this is perfectly inelastic. This is still inelastic. This is an elastic supply curve. And this is perfectly elastic. And then we also define unit elasticity in which case the elasticity is equal to 1.

Now, the question is what determines the price elasticity of supply. One is the ability of sellers to change the amount that is supplied, because there are certain items such as land that cannot be created, and in that case the supply has to be inelastic.

Why? Because, in this equation, the numerator is the percentage change in the quantity supplied. So, if the quantity supplied cannot be changed for a thing such as land that cannot be created, we will have a numerator that is 0. And in that case, the price elasticity will be 0 or that would mean that it is completely inelastic.

So, the ability of sellers to change the amount that is supplied governs the price elasticity of supply. It is also governed by the time horizon, because even in the case of those items for which the sellers can change the amount supplied, this change in supply cannot be entered in a moment's notice. It will take some time.

So, for instance, in the case of ice creams, if the price changes, the sellers would want to manufacture more ice creams and supply it to the market. But this change in the manufacturing capability will not happen in a day. The seller would have to hire more people, the seller would have to or the manufacturer would have to install new machines which will take time.

So, time horizon is also a determinant of the price elasticity of supply. Firms cannot change equipment in short time spans. And so the elasticity is less in the short term.

In the long term, more equipment can be installed or discontinued, newer firms may enter or exit the market, which increases the elasticity. So, in the case of elasticity of supply, there are two things that mostly govern the behavior: one is whether it is possible for a seller to increase the supply or to change the supply, and even if it is possible how long it will take.

Now, why are we interested in knowing elasticity? This is because it changes a number of consequences in the market.

So, let us look at this application. If there is a bumper harvest, what happens to the amount of revenue that the farmer earns? So, what we are saying here is that earlier there was a fixed supply of food grains by the sellers, or in this case, the agricultures. Now, if there is a change in the technology that they employ or if there is a change in the seeds that they use, they are now using high yielding varieties and they are able to increase the output by a very large extent. If that happens, will they earn more or will they earn less?

Now, as you will remember the food grains are a necessity and in a number of cases the demand is very inelastic because whatever happens to the prices, whatever happens to the income people require a fixed quantity of food grains. So, this is what we are representing here. The demand curve is pretty inelastic. So, it is looking very close to the vertical. It looks like the letter I.

The food names have an inelastic demand. Now, earlier the supply curve was this. And now because of a change in technology or shift to high yielding varieties, the new supply curve is the red one. We are seeing that there is a shift to the right in the case of the supply curves.

Now, what happens to the revenue that people would earn? Earlier the equilibrium was at this point. This is the demand curve. This is the earlier supply curve. So, this is the point of equilibrium. This is the equilibrium price, and this is the equilibrium quantity that is demanded and supplied. Now, the curve the supply curve has shifted to the right. And now it is intersecting the demand curve at this point. This is the new equilibrium price. And here you have the new equilibrium quantity that is demanded or supplied.

Now, the revenue that the farmers earn is given by the price of the product multiplied by the total quantity that is in the supply. So, if the price increases, the revenue increases; if the total quantity that the supply increases, the revenue increases. So, earlier the price was given by this figure; the quantity supplied was given by this figure.

And so the revenue is given by the area within this rectangle as shown in green color, because this was the earlier equilibrium. So, from this point, we can get the price that was there; from this

point, we can get the earlier equilibrium quantity. And multiplication of both of these will give you the revenue that was there beforehand.

Now, because of the bumper harvest, the equilibrium is here. So, the new price is this much. The new quantity is given by this line that touches the quantity curve at this point. The new revenue is equal to this P' multiplied by Q' . So, this is the new revenue.

Now, as you can observe in both of these rectangles, this area is the same that is in this area is one and the same. Now, earlier, this rectangle was included in the revenue. Now, in the new circumstances this rectangle is removed, and this rectangle is added. Now, as is very evident from this curve, this area in green color is larger than this area in two colors.

What we are observing is that even though the sellers are able to increase the supply, the agriculturalists have probably invested a lot of money into getting the tractors or into getting more equipment or better seeds. So, they are investing. But what is happening to the total revenue? When the total revenue is going down? Why because the demand curve for food grains is inelastic.

In this case, the result is that a bumper crop is bad news for a number of farmers. Because even though they have increased the supply, there is a decrease in the revenue that these farmers get. So, a bumper harvest in this scenario is bad news for the farmers.

In this case, we are considering that the demand for the food grains is inelastic, but in a number of cases we also observe a differentiation in the market. It is possible that out of say one thousand farmers that are supplying the food grains, there are only 10 farmers who have shifted from the old supply curve to the new supply curve.

In that case, the total amount of supply in the market would not change by too much, but these individual farmers who have increased the supply increase the quantity that they are supplying to the market. So, in that scenario, it is possible for them to increase their revenue. So, for a few farmers, if you have a scenario in which there are only a few farmers who have increased their output.

In that case, because the revenue is equal to the price multiplied by the quantity. So, if there is a very little change in the price and a few farmers are able to increase the Q , in that case those farmers would be able to increase their revenue. But if a majority of farmers are able to increase the output, in that case because the demand for food grains is inelastic, the total amount of revenue that these farmers would be again would go down. So, this is one application of elasticity.

Another application is concerned with the market power of the sellers. So, if the sellers are able to change the supply or the quantity that they are supplying to the market, how much power do they have, how much is their influence in changing the price of the products? Now, this is an important consideration for things such as petroleum.

In the case of the organization of petroleum exporting countries, if they come up with a resolution that we are going to reduce the supply, we are not going to extract as much petroleum. So, in the short term, we always observe that there is a big rise in the price of petrol and diesel. But then how long does this market power stay is what we are now interested in.

What we are saying here is that this is the demand curve, and this is the supply curve as shown in green color. Now, in this example, the sellers are reducing their supply. So, they are shifting the

supply curve to the left. So, earlier it was this green curve, now it is the red curve.

The earlier market equilibrium was at this point. So, this is giving us the price. And this is giving us the quantity that is demanded or supplied. Now, they have shifted it to this point. So, this is the new equilibrium price, and this is the new equilibrium quantity.

Now, if the demand and supply both are inelastic which means that there is very little change in the quantity demanded or supplied because say things are a necessity. So, things such as petrol or diesel are a necessity for the running of the economy. So, in this case, we are observing that the demand curve is pretty much vertical, the supply curve also is pretty much vertical.

If such a scenario occurs, the sellers have a huge amount of market power because if they reduce the supply the price changes by a very large value. So, as we can observe the price earlier was this the new price is this. There is an upward shift in the price of this particular product.

So, the price increases. This is telling us the market power that these sellers have. If they reduce the supply, they can change the price that is there in the market.

If you will remember when we talked about a perfectly competitive market, it means that the sellers and the buyers should not have the ability or the power to change the prices. But if the demand and supply are inelastic, then the sellers have a great amount of market power, but then that is this is in the short term.

In the long term, what happens is that people may shift their demand curves. If the rate of petrol is too high, people would shift to more fuel efficient vehicles or they will shift to electric vehicles, or they will start using public transport, or they will start doing carpooling.

In such a scenario, the demand becomes pretty much elastic because people are now shifting the equipment that they were using. Earlier their equipment required a great amount of petrol or diesel, the new lifestyle requires a much lesser amount. So, now, the demand becomes elastic.

And inelastic demand is shown by this curve which is not that much vertical as we were having in this case. So, here it is a pretty vertical curve. And in this case, it has become much flatter. Also in the long term, the supply also changes because if the price is large, then more and more people would start to extract the oil.

Even those oil firms that were not competitive enough in this market because the prices were low and they had a very high cost pattern of extracting the petroleum, they will now enter into the market because again if you remember a competitive market it allows a free entry and exit.

Now more and more extractors would get into the market, and so even the supply curve will become more and more elastic. And an elastic supply curve is shown by this curve which is now pretty much horizontal. Earlier the curve was having a very great angle, and now this curve is very close to the 0 degrees line.

In the long term, when this happens, when you have an elastic demand and an elastic supply curve, what happens now? Now, again if the seller tries to reduce the supply, so in this case, the curve is shifting from this green line to the red line. So, it is shifting to the left which means that there is a change in the supply. What happens to the prices now? Now, the earlier equilibrium was this where the green points were intersecting.

So, this was the early price, and this was the quantity that was demanded or supplied. In the new scenario, this is the new equilibrium. And this is the equilibrium price, and this is the equilibrium

quantity that is demanded or supplied

As we can observe here because both the demand and supply are very elastic, there is hardly any change in the equilibrium price, but there is a big change in the quantity that is demanded or supplied when the sellers have reduced the supply into the market. This small price difference is telling us that now the market power of the sellers is very less. In the long term, these sellers have a very less amount of market power because the supply and demand curves both become more and more elastic.

What we can make out of this is that the market power of sellers to impact the prices is only in the short run, it is not there in the long run. So, in this lecture, we observed that the quantity that is demanded or supplied in a market depends on a number of factors. It can change because of a change in one or more of its determinants.

So, for certain items, such as food grains, the elasticity is very less; they are pretty inelastic in the demand curves. Why, because even if the income of a person increases he or she will be consuming roughly the same amount of the food grains.

If the price of food grains stays even then the person would be consuming roughly the same amount of food grains. If there is a change in the price of potatoes, even then the people would be consuming roughly the same amount of food grains. So, there is a pretty inelastic price elasticity of demand because a change in the price of food grains will hardly change the quantity that is demanded.

There is very little income elasticity of demand because even when a person is having a larger income or a smaller income, there will be hardly any change in the quantity of food grains that they want. And there is a very less cross price elasticity of demand when we look at the food grains in total.

For instance, if the price of clothes increases, that would not lead to any great difference in the quantity of food grains that are demanded. But then if we look at the market in a much finer detail, if we differentiate between whether a person is demanding the rice or is demanding wheat, in that case we might observe that there are greater elasticities involved.

For instance, if the price of rice increases, the people would want to have less quantity of rice and probably more quantity of wheat. So, in that case, we will start observing price elasticities in the demand for rice. And we will start to observe a cross price elasticity in the demand for wheat. We have observed that in a number of scenarios, there is an elasticity that is involved. Now, whether the demand or supply curve is elastic or not can very easily be made out by looking at the shapes of the curve. So, if the curves are roughly vertical, if they have a shape like the letter I, then it is inelastic.

If they have a shape that is close to the horizontal, then the supply or the demand is pretty much elastic. Now, the importance of knowing the elasticities is that they determine to quite an extent, what would be the direction of change in equilibrium, and what would be the magnitude of change in the equilibrium. For things that have an inelastic demand, there is hardly a change in the demand because of any of the determinants.

In those cases because the demand is inelastic, the sellers have a much greater amount of market power. But at the same time, if the demand is inelastic such as in the case of food grains, then a

bumper harvest might also result in decreased revenue for the farmers because in these cases the demand is inelastic. So, any changes in the supply will have a huge bearing on the prices that are involved.

If the supply is lowered, the prices would increase; if the supplies are increased the prices would decrease to a very large extent because of an inelastic demand. But in the case of items that have an elastic demand, then the changes in the prices will be very less because people will very easily shift to something else. And this also brings us to the point that these changes will have a different ramification in the short term and in the long term. Because in the short term the demands and supplies are pretty inelastic; in the long term more and more sellers can enter or exit from the market.

The buyers or the people who are demanding the goods, they might shift to something else they might go for, say a better vehicle or say some other food grains. Now, in the long term what happens is that the market power of the sellers reduces considerably because the demand and supply both become elastic. So, there is hardly any change in the prices when there is a change in the supplies. So, these sorts of ramifications have to be understood. And they will have a very important bearing in how the market reacts. That is all for today. Thank you for your attention. Jai Hind!

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Module 6
Markets: Places where Economics works
Lecture 3
Government policy

Namaste! We move forward with our discussion on the working of markets and in this lecture, we will explore Government Policy. Now, we had seen in the 10 principles of economics that markets are usually a good way to organize economic activity. The question is what is so special about markets that makes them a good way of organizing economic activity when there are several things that markets do?

1, they permit the expression of free will which means that if I go to a market as a buyer, then nobody is compelling me to buy a certain product. If I find that there is a product say mangoes that are going to increase my welfare, I will purchase mangoes. If on the other hand, I feel that I should purchase apples, I purchase apples.

Nobody is there to tell me what is the quality that I should be buying? So, if I find mangoes and I find that they are not of a very good quality, I might not purchase them. There is no compulsion on me to buy something. So, it is an expression of free will. Now, because a market works on free will, it also permits the expression of a number of choices or freedom of expression.

What it means is that if in a market people want to purchase jeans, then more and more sellers would provide jeans into the market. If more and more people want to purchase suits, then probably more and more number of sellers would bring in suits. So, because there is nobody to do a moral policy in a market so, people are able to express themselves in a much better way. So, it permits the freedom of expression.

Thirdly, there is a fast movement of information. What it means is that suppose in place of a market, we were having the command economy. Now, in that case, there would have been a central planet to decide what good should be manufactured in what quantities, in what qualities, where they should be manufactured and for whom they should be manufactured.

So, there are all these questions of economics that would have to be decided by say a central planner. Now, in the case of a market, the prices provide this information. So, if the demand for something goes up, it will tell the market that this is a product that more and more people want and we have observed before that in the working of a market, if the demand increases without changes in the supply, then the price increases.

Now, this increase in the price will automatically provide information to the sellers that if they want to maximize their profits in that case, they should be bringing more and more of these

goods, more and more of these products into the market and when that happens, when the supply side increases, the prices go down to the normal levels.

So, these prices act as a very quick movement of information, nobody needs to decide what or how much of any particular product should be manufactured, but the prices will give this information. So, prices because they work in the market, they permit a very fast movement of information.

They also permit automatic decision-making because in this case, people are making these decisions automatically, the central government does not have to tell the sellers that ok, the demand for such and such a product is increasing so, why do not you make more and more of these products. These decisions are being made automatically.

And because of all of these, what happens is that we have an increased welfare in the market, or we can also say that there is an increase efficiency because of all of these. So, the market is a very good mechanism to increase the welfare of people because they are doing things that they want to do, and we can make this assumption that people best know what is best for them.

So, the markets allow the expression of this information and because it does everything in a very efficient manner so, it is the way of maximizing the welfare. So, this is why, we say that markets are usually a good way to organize economic activity, but at the same time, the government can sometimes improve the market outcomes.

Now, why would we require governments to do the market outcomes? If everything is being done by the market in the most efficient manner, why should we do government at all? Now, the government is required because market has a few prerequisites for it to function properly. What are they? We have seen before that a market can only function if you have property rights.

So, the seller must know that the only way in which he or she can increase his or her property is by having more and more profit, by selling more and more of the goods. Now, if it was possible for people to just snatch these goods from somewhere else to snatch the money from somewhere else, then in that case probably, the market would fail to function because whether or not we have the market, you can always go and snatch the products.

So, the working of property rights is extremely crucial for the market to function. Another thing that we need is institutions. Now, if I feel that my property rights have been violated, what should I do? I require institutions such as the police or the judiciary to enforce the property rights.

So, not only should property rights exist, but at the same time, they should also be enforceable and thirdly, they should not be an externality because if there is an externality, then probably, the market will not be to the highest amount of social welfare. Now, externality as we have observed is the property or the phenomenon in which the actions of a doer have a bearing on the welfare of a bystander who has got nothing to do with that particular action.

Good examples include things such as pollution. So, a polluted by polluting the environment, he is maximizing his profits because he is not spending money to install a pollution controlling device, but this pollution is going to impact the health of so many different people.

So, if you permitted this sort of a phenomenon to go on, then probably you will have so many different industrialists just who would be polluting the environment to maximize their profits by

reducing the cost of production that are involved, but at the cost of that health of so many different people. So, this is something which is not giving the highest welfare to the society, it is not giving the highest welfare to the people to the citizens.

Now, this is where the government needs to step in. The government needs to say that ok, you want to maximize your profit that is fine, but you are not going to do this at the cost of the health of other people. So, the government is required whenever there is an externality because the externality reduces the efficiency of the market; reduces the efficiency of the market by not permitting the maximum amount of benefit.

Similarly, in the case of positive externality, since it is education or health care of people. Now, it is possible that if a market is only working on the profit motive, then things such as health care of the masses might not get completely provided for. Now, health care of the society is an example of positive externality.

So, if somebody vaccinates himself or herself, he or she is not protecting himself or herself but is also acting in a way to stop the spread of infections through the whole of the society. Now, such things need to be incentivized. Now, who is going to incentivize them? The market is not going to incentivize, and which is why we need the working of governments.

Another thing where we require the working of governments is where people have market power. Now, what is market power? Market power is the ability of one or a few number of buyers or sellers to influence the market prices. A very good example is a person in a village who owns a well and there is a drop. Now, this person can charge any amount of sum because he is the only one in the village who has a well.

Now, this person can influence the market prices. Now, this is known as market power. Now, in the case of a market which has certain players who are exhibiting market power, we will observe a number of things that reduce the benefit of people. So, for instance, we will start observing that there are certain people with market power who force people to work without paying them money or by paying them very small amounts of money.

So, for instance, in our country also, we had the system of begar. In begar, people used to force others to work for them without paying them anything. Now, in our country, the system of begar, it was abolished through the constitution. So, which is why we require the working of the government? If we did not have the government, probably begar would have continued.

Another example is employment of children. Now, children may not be in the best position to bargain for their rights and in a number of cases, we observe that children are exploited. Now, through much of the 18th and 19th centuries, we observed that industrialists were using children to work in their factories and in a number of cases, these children used to get involved in accidents, they used to lose their limbs, they used to die.

Now, who is going to fight for the rights of children? If not the children and if not the market, then government has to step in. So, in cases where there is market power, where there are certain players or certain actors in the market who are able to influence the prices, who are able to dictate their terms, we require the working of the government to maximize the welfare of the society.

So, in all of these, what we are observing is that we require government to maximize the wel-

fare of society. So, what is being expected of the government is that the government will provide for a mechanism that permits the market to work efficiently, to have all the benefits of the market, but to overcome the shortcomings that the market would have without the supervision of the government.

So, which is what brings us to the working of government policies. Now, in a number of cases, the government influences the market outcome through things such as price controls or taxes and in a number of cases, things might be outrightly banned. Now, we are not talking about things that are completely banned by the government because that comes under the ambit of law.

But here we are talking about ways to nudge the market outcomes that is if the government wants that people should have more of minimum wages, that is people should be paid a bare minimum for the services that they are rendering, then what are the mechanisms that the government has?

If the government wants to say minimize the use of a certain good or a service that is harming the society, what are the mechanisms that government has? Well, one mechanism is outright banning that particular thing, but if the government wants to reduce the influence, then what are the mechanisms with the government?

Now, in this case, two ways of contacting market outcome are price controls and taxes, but these impact the running of the market and so, must be used with care because we have observed before that markets are generally a good way of organizing economic activity.

So, if you are influencing with the market, it should be done in a very settled manner, the government should not influence the market to such an extent that the market forces themselves to stop operating. So, we will observe what are the kinds of influences that, these price controls and taxes can have on the market outcomes. So, let us explore the impact of these interventions beginning with price control.

Now, price control can have two formats: one is a price ceiling and the other is the price floor. Now, if you consider a room, then you will have the ceiling above and you have the floor below. So, price ceiling is the maximum price that can be charged. Price floor is the minimum price that can be charged or must be charged.

So, price ceiling is the legal maximum on the price at which a good can be sold. So, when we are talking about price ceilings, this is the maximum that somebody can charge such as the maximum cost a company can charge for say electric vehicles. Now, a good way of understanding price ceiling is our example of the village person with a will in a (Refer Time: 16:28) situation.

Now, this person may charge any amount. So, suppose he charges 500 rupees for a bucket of water. Now, the government can intervene, and the government can say that no, we are not going to permit you to charge 500 rupees for a bucket of water, the maximum that you can charge is say 20 rupees. Now, when the government puts up certain intervention, then this is known as a price ceiling.

The maximum that you can charge your customers, the maximum the sellers can charge their buyers for any particular good or service is the price ceiling and in a number of cases, this is legally defined. So, it is the legal maximum on the price at which a good can be sold. A price floor is the legal minimum on the price at which a good can be sold such as the minimum you need to pay a

company that is selling solar cells.

Now, in a number of cases, we have things such as a minimum support price. So, for several food grains, this is a price that the government has set that is the minimum that needs to be paid to the farmers because if you pay anything less than the minimum support price, then probably the farmers will not be able to recuperate the cost of agriculture. So, this is the minimum that needs to be paid.

Similarly, we have minimum wages which means that this is the minimum amount of wage that you need to pay to a person when he or she is providing you his or her services for a day because this is the minimum that is required for any person to lead a successful life. If you pay this person less than this amount, then probably he or she will have to cut down on the amount of food that they are getting or the clothes that they are wearing.

So, this is the minimum that we need to pay. Now, such a price which is the legal minimum on the price at which a good can be sold is a price floor. Now, how does the government implement these? So, we can we will look at the price ceilings as well as the price fields.

Now, here we are observing that if you make the demand and the supply curves, now here again the demand curve moves from top left to the bottom right because as the price increases, the quantity demanded will go down so, which is the law of demand. In the case of the supply curve as the price increases, the quantity supplied increases which is the law of supply.

Now, both of these curves intersected in this point which is the point of equilibrium. So, at this point, we have an equilibrium price so, if you draw this horizontal line, the point where it cuts the price axis, or the y-axis gives you the equilibrium price. You also have the equilibrium quantity, which is if you draw a vertical line, the point where it cuts the x-axis will give you the equilibrium quantity that is being demanded or supplied in this market.

Now, at this equilibrium, the quantity demanded is equal to the quantity supplied and the price that it gives you is the equilibrium price. So, if the market is working as it is that is without any interventions, then this is the equilibrium price and the equilibrium quantity that are being demanded and supplied in the market.

Now, the government may say that there is this price ceiling that is this is the maximum price that anybody can charge for the good. Now, in this case, what we observe is that this the price ceiling that is the maximum that anybody can ask for so, this price ceiling is telling us the maximum amount that can be charged.

Now, here we can observe that the maximum amount that can be charged and this is the the amount that the market is already charging which is very less than the maximum that can be legally charged. Now, in this case, the price ceiling does not have any impact on the market because you are well within the price ceiling.

The market has reached an equilibrium at a point where the price is less than the price ceiling and so, we call this a non-binding price ceiling, it is not binding on the bias and descendants because in any case by the natural equilibrium is bringing the price to a point which is less than the price ceiling. So, this is, this this graph tells us that there is no impact of a non-binding price ceiling.

But what happens if the price ceiling is less than the equilibrium price? That is the market

brought us to this equilibrium, this is the equilibrium price, and this is the price ceiling. So, there is a difference between both of these. So, here we are finding a difference between the natural equilibrium price so, this is something that the market has reached naturally without intervention and this is the price at which the government is intervening, here we have intervening.

Now, the question is what is the impact of such a price ceiling which is less than the natural equilibrium price that the market will provide you? Now, at this price ceiling, the quantity that is supplied is given by this point, where the supply curve intersects the price ceiling. So, this is the quantity that gets supplied in this market. So, this point will tell us the quantity that is supplied in this market at this price.

Because remember that when we talked about the supply curve, the supply curve tells us the quantity that the sellers are able and willing to supply to the market at different price points. So, if the price increases, people want to supply more. If the price reduces, people want to supply less. So, the amount of goods or services that people will be able and willing to supply to the market is given by this quantity where the supply curve is intersecting with the price curve.

Now, the quantity that is demanded by the consumers at this price point is given by this point. Now, this is the point where the demand curve is intersecting with the price. Now, here again you will remember that a demand curve tells us the quantity that is demanded at different price levels. So, if the price of something goes down, then people start to demand more and more of that particular good or service.

So, at every point, the demand curve tells us what is the quantity demanded at that price point. So, at this price point, which is the intervention price point or the price ceiling that has been set up by the government, the quantity that is demanded is given by this vertical line which intersects this curve at this point. So, this is the quantity that is demanded in the market, this much; this much amount of quantity is demanded in the market and this much amount of quantities supplied in the market.

So, there is a difference between the quantity demanded and the quantity supplied. The demand is more, the supply is more. Now, if you remember the law of demand and supply, the demand curve and the supply curve intersect each other at a point that makes the quantity demanded equal to the quantity supplied because of which there is no shortage.

But, at this price point, at the price ceiling which is binding, we are observing that the demand is much greater than the supply. So, in this case, the market will observe a shortage of goods. Now, shortage is the difference between the quantity demanded and the quantity supplied.

Shortage is defined as a situation in which the quantity demanded is greater than the quantity supplied to the market. Now, what are the impacts of a shortage? Now, obviously, as we have observed, the market is a good way of organizing economic activity. So, at the natural equilibrium point, the market will reach the situation where there is no shortage.

So, everybody who is able and willing to pay at that price point will get the stuffs, but when you have a binding price ceiling, then the shortage will manifest in the form of long queues. So, because there are less goods that are supplied to the market, more and more people want to have that good so, there will be long queues, people will waste their time standing in the queues, people will waste their time irritation and frustration of not being able to get that good.

Now, there will be certain people who would say that ok, the government has said this price ceiling of 10 rupees, let me give you 12 rupees, you give me this product or let me give you 20 rupees and you give me this problem. So, the people will always try to bring the market to the natural equilibrium point, but because of the price ceiling, if it is legally enforced and if it is enforced properly which means that people are not able to cross this ceiling by means of black marketing or by paying bribes.

So, if that happens, then there will be a shortage of this market. So, there will be long queues, lost time, there will be unfairness because there will be discriminatory selling to close friends or relatives. So, the seller would say that ok, I only have 10 pieces of this particular good, there are 100 people who want to have this good, whom do I sell it to? And I cannot increase the price so, I cannot increase my profit.

What the seller would do is ok, let me give it to my relatives, let me give it to my friends. We will start observing discrimination in the society. We will start observing black marketing and bribery. So, even though legally you can sell this good for 10 rupees, there will be a black market that will come up in which people will be able to buy this good for 100 rupees.

People will try to bribe the shop owners to allocate them the goods, and will observe rationing. Now, in the case of rationing, the government will say ok, no there is nobody who will be able to purchase more than say two pieces of this particular good.

Even if there are people who want more of these goods because say they have a larger family or because there is say some medical situation or this person is going out and so, he he or she requires more of these goods because he or she will not be able to go to the market every day so, in that case, people generally want to have more of the goods, but because there is a price ceiling, the government might even have to enforce rationing.

The government will say no, every day you can only have two ah; two pieces of this particular good, say 2 pieces of bread now, in that case, you cannot say bring 14 pieces of bread and store it into your fridge, you will have to go to the market every day so, that is rationing.

There will be many potential buyers who do not get access to the goods at all because there is a shortage. So, not everybody will get the goods. There will be long term impacts including the reducing supply, not innovating, not doing maintenance, a reduced quality and so on.

A very good example is the rent ceiling. So, what the government did sometimes back was that they said that the landlords are charging exorbitant rents from the tenants. So, the government said ok, nothing doing, you cannot charge more than this particular amount. So, suppose in the market the landowners were charging 20,000 rupees for a particular flat and the government says no, you cannot charge more than 5000 rupees. What will happen?

One, the landowners will find it no longer lucrative to put this flat into the market. So, they will reduce the supply because then they were willing to put this flat up for rent for 20,000 rupees, but for 5,000 rupees, it does not make sense for them. And for those landowners who actually put the flat on for rent, what they will do is they will cut down on something, they will cut down on maintenance, they will not upkeep the flat, they will not paint it regularly.

So, the tenant who gets into this flat will find that all the walls have peeling paints, the windows have broken glasses, the taps do not work and things like that because it is now no longer

lucrative for the landlord to maintain this flat will start observing that people stop doing any maintenance, there is a reduced quality, people stop innovating and people try to take things more and more away from the market. So, the supply reduces even further.

And in a number of cases, the government will find it difficult to improve the norms. So, we may start observing difficulties in enforcing norms which actually defeat the government interventions. So, if the government needs to intervene, the government should be prepared to enforce the norms otherwise, it does not make any sense.

Another impact is the impact of a price floor. Now, the price floor is the minimum that can be charged. Now, here again, we can have a non-binding price floor in which case this is the natural equilibrium point; point without intervention and this is the intervention. The government in this case for example, is saying that this is the minimum wage that you need to pay to people, but the natural equilibrium has brought the wages to this one.

Wages like other goods also have a demand and a supply. The demand is by those people who want to employ others and the supply is those people who want to give their wages or who want to sell their wages because not everybody wants to work for wages. So, those people who want to sell their wages, they will be supplying to this market and those people who want to hire others, will be the buyers in this market.

We are talking about the market for labor. Now, in this market as in all the other markets, there is a demand curve, there is a supply curve and the point where both of these meet is the natural equilibrium one which gives us the equilibrium price and the equilibrium quantity.

In this case, the government is saying that the minimum wages that you should be paying is so, and so which means that in the national market suppose everybody is being paid 500 rupees for a day worth of labor, but the government says the minimum you need to pay is 100 rupees now, because the market is already paying 500 so, this becomes a case of a non-binding price floor.

This price floor is not binding on the market. So, it will not have any impact on the market. On the other hand, we can have a situation where the price floor becomes binding. Now, when the price floor becomes binding, the quantity that is demanded is given by this point where the demand curve is intersecting with the price floor. So, the quantity demanded will be this much.

The quantity supplied is given by this point where the supply curve intersects with the price floor and the quantity that is supplied will be given by this point. Now, in this case, what we are observing is that the quantity that is supplied to the market is more and the quantity that is demanded is less.

Now, why is that so? Because as we have seen in the law of supply, as the price increases, the quantity supplied also increases. Now, because the price floor in this case is more than the equilibrium price so, more the price means more the quantity supplied. On the other hand, in the case of the law of demand, if the price increases, the demand falls.

So, the quantity demanded is now less which means that suppose if the market was paying 500 rupees for a day of labor and the government says no, you cannot pay 500 rupees, you have to pay 700 rupees for every day. Now, for 700 rupees there would be a number of people who were not willing to work for wages for 500 rupees, but for 700 rupees, they would say ok, let me work

in the market because every day I will be getting 700 rupees.

Now, the quantity supplied will increase, but the quantity demanded will decrease because there were a number of people who were able and willing to pay 500 rupees. But when it comes to 700 rupees, there will be a number of buyers of labor or the employers who say that no, 700 rupees is a bit too much because by hiring this person, I am only able to get a revenue of 600 rupees.

So, if I pay him 500 rupees, I have 100 rupees of profit, but if I hired this person for 700 rupees, I will be at a loss of 100 rupees for each labor that I am hiring. So, the demand will go down. So, in this case, what we are observing is that the quantity supplied is more, the quantity demanded is less which means that there will be a surplus in this market.

So, more and more people want to work at this wage, but fewer and fewer people want to hire people at this high wage. So, this leads to a surplus. And a surplus is defined as a situation in which the quantity supplied is greater than the quantity demanded.

Here again, it will have certain impacts such as selling which is possible only for a few sellers who can appeal to rational, familial or other ties which means that the people who want to work for these wages would not find the work when they go to the market because the price is a bit too high. But then, they will probably go to one of their relatives and say that ok, you are hiring such and such number of people, why do not you throw them out and why do not you hire me because I belong to your own family.

If you are paying 700 rupees, let it remain within the family. We will start observing that people are now using their family and friends, people are using their friendly ties. So, people would say ok, your father is employing so and so number of people and you should ask your father to hire me. So, in this situation of surplus, selling is possible only for the few sellers who can appeal to these ties.

There will be a loss for sellers due to unsold inventory. There will be a large number of people who want to sell their labor, but they are not getting any market for them. So, they have got nothing to do, but they can only sit down. So, in that case, we are observing that there is a loss for these people.

A number of these people would have happily worked for 500 rupees so, at least they will be getting 500 rupees every day, but when the government increases the floor to 700 rupees, then these people are completely out of the market. In that case, they will be earning 0 rupees, this is also a situation that will come up.

And the long term impact will be closing of different industries because people are not getting labor at requisite or natural equilibrium rates, there will be job losses. And also there will be a number of situations where the government will not be able to enforce these points because on paper, people would be saying that we are paying 700 rupees, but when the labor comes, the employer might say ok, I am going to pay you 500 rupees.

But, you sign this paper saying that you are receiving 700 rupees, either you do this or I will throw you out. Because I do not have any other option, I cannot pay you more than 500 rupees, but the government is insisting that I pay you 700 rupees so, let us close the papers. So, the enforcing of these price floors at times also becomes very difficult, but at times, these are important.

So, markets are usually a good way to organize economic activity, but the point here is usually, not always because if you allowed the market to work as it is, then there might be cases of exploitation, there might be cases in which people are reducing the welfare of the society so, the government will have to intervene, but if the intervention is a bit too high.

Suppose in place of 500 to 700, the government had said that ok, in place of paying 500 rupees, the price floor is 550 rupees or say 520 rupees, then probably the intervention would be much more fruitful because it would actually increase the amount of remuneration to different laborers. But if these interventions are used to a very large extent, then probably, they will defeat the purpose. So, these interventions are important to increase the welfare of the society to reduce exploitation, but at the same time, they have to be used with a very great amount of concern and with a judicious amount of usage.

Another intervention that the government does is through taxes. Now, the government collects taxes for their functioning and for the financing of public projects. So, as we had observed, there are a number of sectors such as health care or education where the market may not provide sufficient quantity and quality of goods.

Now, because these are those sectors that have a very large positive externality, a person who is educated is not only benefiting himself or herself but is also an asset to the society. A person who is healthy is not only protecting himself or herself but is also an asset to the society because he or she is also preventing the spread of diseases.

These are things that need to be incentivized, but the market may not incentivize these activities because the market works on a profit motive. So, the government will have to intervene, the government will subsidize these sectors, but to subsidize these sectors, the government also requires funds. Now, where did the government get these funds from? One option is taxation.

So, the government taxes different people especially, those activities that need to be brought down, so they will be taxed at a higher level. But a number of other activities such as earnings will also be taxed and these taxes, the funds that are received through these taxes they will be used for the working of the government and they were also be used to subsidize these priority sectors and these days, we are also observing that the government is using tax money for conservation purposes.

Such as this, pollution tax businesses will face higher taxes on the gas they use in a bid to cut pollution. What the government is saying here is that because pollution is having a negative externality, we are going to put a higher tax on the use of fossil fuels so that it becomes disincentivizing for people to use more and more of these fossil fuels. So, here the government is using the tax for conservation procedures.

Federal carbon tax jumps 50 percent. So, in Canada, the government is putting a carbon tax so that if people are emitting carbon, they will have to pay for it. Car tax what you need to know about vehicle excise duty. Now, here again, because cars pollute the environment, the government puts up a tax on cars to reduce their usage.

Excise tax: the right step to combat plastic pollution. Now, in this case, the government is trying to bring the supplies down. How? So, we have observed that in the case of the supply curve, the supply curve looks like this. So, we have the price, and we have the quantity. Now, in the case of

a supply curve, when the price is less, the quantity supplied is less. When the price is more, the quantity supplied is more.

Now, when we talk about the excise taxes, what they do is that they increase the cost of making funds which shifts the curve to the left. So, what we are saying here is that we had observed in the case of the supply curve that an increase in the cost price of making or the increase in the cost of making things, shifts the curve to the left, that is it reduces the supply, what it means is that for any given price point.

Let us say at this price point, earlier the market was able to supply this much amount of the product, but now, the market was only able to supply this much amount of the product. So, the quantity that has been supplied reduces if we increase the cost of making the things and a good way of increasing the cost of making things is through tax increase. So, in this case, the government uses excise tax to combat plastic pollution so that less and less amount of plastic is imported for manufacturing.

Now, whenever we have a taxation, this tax may have to be paid by the buyers, they have to be paid by the sellers or by both of them. So, for instance, if the price of this bottle goes up, who is going to pay this price? Is the company going to pay this price out of its profits or will the buyers have to sell out more money to get this bottle?

Who is paying the price of these plastics is the next question, which brings us to tax incidents. Tax incidence is the manner in which the burden of a tax is shared among the participants in the market. So, who pays, the buyer pays, the seller pays or both of them pay? Now, we will look at the complete impacts of taxation in a later lecture, but in this lecture, we are concentrating on who will pay the taxes and by how much.

It is important because in certain cases, if say artisans have to pay the taxes for something, then in that case, they might lose out on their jobs because their profits are already wafer thin and so, if the revenue reduces, then probably, they will be out of the jobs. So, which is why we need to be very careful about the tax incidence.

Now, what is happening in the case of taxation and if the government says that we are applying a tax only on the seller which means that the government is saying here that when the manufacturer makes this bottle, then the manufacturer will be taxed, the more the number of bottles will make the more will be your tax the the government says that.

Does that mean that only the manufacturer will have to pay for the taxes? It is what we are trying to analyze here. In this curve, this is the demand curve, this is the supply curve and because of a tax, there is a shift in the supply curve to the left because we are adding a tax and we are taking this tax from the sellers which means that the sellers have to pay more to make each bottle.

The cost of making goods has increased and so, the supply curve is shifting to the left. Now, what happens here? Earlier, the equilibrium price was this much. So, this is where the earlier demand and supply curves were intersecting each other, but now, what is happening is that because the new supply curve is here, this is the new equilibrium point.

The equilibrium point has shifted from this point to this point. Now, what is happening is this is the price that the buyers will have to pay to get this bottle why? Because at this point, the point where it is cutting the demand curve, this is telling us the equilibrium price that the buyers pay,

and this is telling the equilibrium quantity that they will be getting.

At this equilibrium quantity, the price that sellers get is given by this point. So, in this case, this is the price that the buyers pay, this is the price that the sellers get and earlier, the equilibrium price was this. So, in the case of a normal functioning of the market without the taxation, the price that the buyers pay is equal to the price that the sellers get, but with taxation, the buyers pay more, the sellers receive less, and the difference is the tax that the government gets.

It is important to note here that this share of what the buyers were paying now and had to pay earlier is the share of the buyers in the amount of tax. And the price that the sellers are getting now is this earlier they were getting this price. So, this is the seller's share. Even though we have added a tax only on the sellers, the tax is distributed between the buyers and the sellers.

This is where we can talk about the tax incidence. Even though the government put this tax only on the sellers, the buyers also have to pay a share. So, what happens? 1, the market activity is reduced because less goods are sold in purchase. Earlier, the quantity that was supplied and demanded was this, the new quantity is this. So, the market activity has gone down, it has reduced and 2, the tax burden in this case is being shared by the buyers and the sellers.

Now, the government can do one other thing, the government can say that we are going to put a tax only on the buyers. Now, in that case, the government will say that ok, the price at which this bottle was being sold, we are going to add to that price so that only the buyers will have to pay because they are purchasing this bottle.

Now, what happens in the tax in the case of tax incidents in that case. Now, because the government has added to the price, the demand will go down. So, in this case, this was the earlier demand curve, this is the new demand curve because we are putting the tax only on the buyers, this and the supply curve remains the same.

Now, here again the point where the supply curve is cutting the new demand curve is giving us the equilibrium quantity that is now demanded or supplied in this market and because this point is where it is cutting the supply curve so, this is the price that the sellers are getting. Earlier, the price without taxation was this. So, this was the price that the buyers were paying, and the sellers were getting.

Now, the price that buyers will have to pay for this much quantity will be given by this point where the vertical intersects with the earlier demand curve. So, this is the price that the buyers will have to pay. Now, in this case as well, we are putting a tax on the buyers only, but we will have a buyers share because earlier the buyers were paying this amount. And now, they have to pay a higher amount so, this is the share of the buyers.

Earlier, the sellers were getting this amount, but now they are getting this amount so, there is a share of the sellers. So, in this case as well, even though we have added, we have put at some buyers only, the tax gets shared between the buyers and the sellers and here as well, the market activity is reduced because earlier the quantity demanded or supplied was this, the new quantity that is demanded or supplied is this.

There is a reduction in the quantity that is demanded or supplied in this market. So, the important thing to note here is that even if you put a tax on the buyer only or on the seller only, the tax will be distributed between the buyers and the sellers. Now, the question is in what ratio? Suppose

there is a tax of 1 rupee on this bottle so, how much amount will be paid by the buyer and how much amount will be paid by the seller?

This again brings us to the topic of elasticity. Now, if the demand is inelastic and the supply is more elastic, we will find that the point where it cuts is way higher than the point without the tax. In this case, the buyer's share is more, the seller's share is less. In the case of an inelastic demand, the buyers will have to pay more.

In the case of an inelastic supply, here the supply curve is now becoming more vertical. So, in this case, the sellers will have to pay a larger share of the tax burden which is telling us that whichever curve is more inelastic, that party will have to pay more. If the demand is inelastic, the buyers will have to pay more. If the supply is inelastic, the sellers will have to pay more.

So, when we talk about the incidence of the tax burden, then the tax burden is shared between the buyers and the sellers, but the amount that each party will be paying will be determined by the elasticity of demand or support. So, what we are getting here is that the largest share is faced by that party which has the inelastic curve.

Now, we have seen before that elasticity depends on whether something is a necessity or whether it is a luxury. In the case of luxuries, we have a demand that is more elastic. In the case of necessities, the demand is very inelastic. So, if there is a tax on something that has an inelastic demand, things like food - in the case of things like food because that demand curve is inelastic so, the buyers will have to pay more.

In the case of things that are luxuries so, if one might say imposes a tax on a luxury car, then because luxuries have an elastic demand so, in that case, the burden on the buyer will be very less so, the buyer will have to pay less of the amount and probably, the seller will have to pay more why?

Because even if there is an increased amount of taxation in the short run, the seller or the artisans who were involved in say painting of the car or making it through a handmade fashion, they will not be able to shift to some other profession so, they are having a larger in elasticity in their supply terms and when that happens, the sellers will have to pay the larger share of the tax burden.

Now, in this case, what is happening is in the case of luxury items such as luxury cars or yacht, the artisans who are involved in painting of these things or in handcrafting different components of the luxury cars, they are extremely poor and when the government imposes a tax on these luxury items, this tax burden goes to the seller which means that it goes to the artisans because they have the inelastic supply whereas, the demand is more elastic.

If the government puts tax on luxury cars probably, the rich people will shift from buying luxury cars into say buying luxury homes or say buying a private jet. Now, in such cases, whether or not the government should tax things, it becomes a bit more intricate because the tax burden is falling more on the seller that is the RTCs.

So, taxing luxury products such as private jets, yachts or luxury holidays with elastic demands and inelastic supply may hurt the sellers who are often poor workers more than the buyers who are the rich. Taxes, though they are a tool for conservation, have to be used with extreme caution to ensure that it does not have a very large social cost.

So, in this lecture, we had a look at the government interventions in the form of price controls, price ceilings and price floors and taxation and we examined what is the incidence of tax burden on the buyers and the sellers and the bottom line here is that if the buyers have an inelastic demand, they will have to pay more, if the sellers have an inelastic supply, they will have to pay a larger share.

The government can intervene with the market outcomes, the government has to intervene in a number of cases to ensure that the market works in a manner that is beneficial for the society, but because we have these negative side effects of any such intervention, these tools have to be used with extreme problems.

That is all for today. Thank you for your attention. Jai Hind!

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Module 7
Markets, Welfare and Conservation
Lecture 1
Surplus and market efficiency

Namaste! Today, we begin a new module which is Markets, Welfare and Conservation. This module will have 3 lectures - surplus, market efficiency and the cost of taxation and international trade. So, let us begin with Surplus. Well, we have seen in the principles of economics that trade can make everyone better off and also that markets are a good way to organize economic activity. Now, the question is why does trade make everyone better off and why is the market the best way to organize economic activity?

Well, one major thing that happens in the case of a market is that there is nobody to tell a person what is good for him or her. Essentially a buyer does what he or she perceives to be in the best interest of himself or herself. Similarly, when the seller decides to sell a particular good at a particular price he or she is selling that good at that particular price because he or she feels or perceives that selling the good at that particular price is going to be beneficial to him or her.

Essentially in the case of a market everybody is trying to maximize his or her welfare or his or her profits because of which markets become very important tools to organize the economic activity. Because in this case there is no third person to dictate to a person that he or she should be buying such stuff at such price or he or she should be selling such stuff at such price. Because making this decision for the whole of the economy is going to be extremely difficult.

But when you permit people to make these decisions by themselves by perceiving what is in their own best interest and remember that a person is in the best position to determine what is good for him or her or what is best for him or her. Now, in the case of a market because everything is everybody is trying to maximize his or her benefits.

Everybody is trying to work in their own best interest so, in that case if we permit a market to work by itself then there would be a maximization of the self interest of everybody which is why markets become extremely important tools. Not only for the working of the economy, but also for the working of the society because in the case of a market the well being is maximized for the maximum number of people. But, the question is how do people decide what is best for them.

What are the things that are going on in their mind when they decide to, say, when a buyer decides that I am going to purchase this pen for say 20 rupees, the question is what is going on in my mind that I should purchase it for 20 rupees? Why not 21 rupees? Why not 22 rupees? Why not 30 rupees?

How do I get to this value of 20 rupees for this pen and similarly, when a seller decides that he or she is going to sell this pen for 20 rupees, the question is why does he or she not sell it for 15 rupees and also why does he or she not sell it for say 30 rupees? What brings us to this golden price value of 20 rupees?

That is the question that we are going to dissect in this particular lecture that is surplus. So, in short the buyer is trying to maximize his or her own surplus or welfare and similarly the seller is trying to maximize his or her own surplus or the welfare. Now, the thing is how we reach this value of surplus and how we can make use of this quality of surplus or welfare to reach our demand and the supply curves, is what we are going to see in this particular lecture.

Why does a buyer purchase anything different goods have different values for buyers. Now, what is value? A value is the importance of something. So, there is a value of most of the things in the eyes of most of the people, but then this value is going to differ from person to person. If I am interested in writing, say if I am a student or I am a teacher or I am a bureaucrat, then I have a utility for a pen. So, I have a value for a particular pen.

But, it is possible that there is a person who is completely illiterate and does not know the value of writing, he does not know how to write. Now, in that case a pen would hardly have a value for this person. Similarly, if I am hungry I will put a greater value on food than when I am not hungry. So, value depends on the buyer; value depends on his or her status; it depends on his or her academic abilities; it depends on his or her needs.

And, because needs change with time whether a person is hungry or not, whether a person has just run out of a pen before signing say a very important document or somebody has run out of a pen just before an examination, then that person will put a greater value to a pen as compared to another person who say has 10 pens with him.

So, value varies from person to person and value is what decides how much am I going to pay for any particular good. So, different goods have different values for buyers and these goods are available at different prices which means that suppose, I have a value for a pen and I say I think that this pen is going to provide me a benefit which is say equal to 50 rupees. Now, in the market if I go and purchase a pen I will find pens at different prices.

So, there can be a pen for 5 rupees, there can be a pen for 5,000 or say even 50,000 rupees. Now, the value that I am putting to the pen at this particular juncture is 50 rupees. So, that would help me determine which pen I should go for. Now, suppose I am only going to use a pen for normal writing.

And it is not going to have a sentimental value for me, so, in that case probably I will go for a 10 or 20 rupee pen. But, suppose I am gifting a pen to somebody who is very important and I am attaching a sentimental value to this pen, I would want that person to hold this pen dearly for say a number of years. Now in that case the value that I will put on the pen will be much greater. I will probably go for a pen that is a very luxurious pen or probably that is gold plated because I am attaching a value to that pen so that it remains with the person for a very long period of time. Now, if I have set a thought that I should be using or I should be gifting a pen which is gold plated in that case I might even go for a pen that is say 2000, 3000 or 10000 rupees price. So, the value and the prices can help a buyer determine which particular good he or she should go for. So, dif-

ferent goods have different values for buyers and these goods are available at different prices. Now, if the value of a good is greater than its price, the buyer may purchase the good and enhance his or her surplus meaning that currently if I am out of pens and I am putting a value for a pen at 50 rupees and suppose, I go to the market and I get a pen of my liking for say 20 rupees. Now, in that case the value that I was putting to the pen was 50 rupees, the price is 20 rupees. So, essentially in my mind I will think that ok I am at a profit and this is the profit of 30 rupees. Now, mind you, I am not getting these 30 rupees, but it is just that I am thinking that something that has a value of 50 rupees I am able to get for 20 rupees. It is very similar to when we decide which particular vehicle to get or say which plot to buy or which house to buy. Now, suppose I look at different houses and I figure out that ok, this house has a valuation of say 70 lakhs of rupees and if this house is available in the market for 50 lakhs of rupees. Then it might go on in my mind that ok, the value is 70 lakhs, I am able to get it for 40 lakhs. So, there is a difference of 30 lakhs between the price and the value. I may hold this house and probably I might sell it at a later point of time for 70 lakhs of rupees. Now, in this case when I purchase the house I am not getting that 30 lakhs of rupees, but I am happy because I am thinking that I am getting something that has a value of 70 lakhs and I am only getting it for 40 lakhs of rupees. Now, similarly, in the case of any good or service that we are purchasing, so, if the value of the good is 50 rupees, the price is 20 rupees then in the mind of the buyer there will be a thought that I am getting this thing of a higher value at a lower price and this difference is known as surplus. Consumer surplus is the amount a buyer is willing to pay for a good minus the amount the buyer actually pays for it, meaning that suppose I was willing to pay 50 rupees for a particular pen, but I got it for just 20 rupees. In that case the difference between 50 rupees and 20 rupees is the consumer surplus that I am getting. The amount a buyer is willing to pay for a good and what is the amount that a buyer will be willing to pay for a good, it will be equal to the valuation of that particular good in the mind of the buyer. If I perceive that this pen is having a value of 50 rupees, so, 50 rupees is the maximum that I am going to pay for it. I am willing to pay 50 rupees for it because that is the value of this good in my mind, but it is available for just 20 rupees. So, the difference between the amount a buyer is willing to pay for the good and the amount the buyer actually pays for it, is the consumer surplus. This is related to the concept of willingness to pay the maximum amount that a buyer will pay for a good and this is an indication of the value of the good to the buyer. Now, what we are saying here is, if I perceive that this pen has a value of 50 rupees will I pay 60 rupees for it? Probably not. Why? Because the value is 50 rupees, so, why should I be paying 60 rupees? Will I be paying 51 rupees? Probably not because here again the price is more than the value. But, if the price is also 50 rupees and my value is also 50 rupees, so, in that case I might pay for it. Now, here again the thing is I might pay for it because my surplus remains the same whether I purchase this good or not. Or to put it in other words, suppose I have rupees 500 with me and if I use it to buy this pen for 50 rupees then I am only left with 450 rupees because I have spent these 50 rupees to buy this

pen. But, earlier the total value that was with me was 500 rupees and now, also the total value is 500 rupees. So, in that case I will be ready to purchase this pen. But, what happens if I am able to get this pen for a lot less? So, the point is in place of 50 rupees. Suppose I am able to get this pen for 20 rupees.

In place of 50, this is 20 rupees. So, I am left with 480 rupees. So, what is the total value that is with me now? So, it is 480 rupees plus 50 rupees because 50 rupees is the value of the pen that I am putting. So, the total value with me is now 530 rupees. So, I began with a value of only 500 rupees.

This is the initial value, but after the transaction I have 530 rupees. So, essentially with this transaction I am able to increase the total value that remains with me and if economics says that every buyer is trying to maximize his or her own assets. So, earlier the asset was only 500 rupees, but now the asset is 480 rupees plus this pen and in my mind the value of this pen is 50 rupees. So, the total asset with me now is 480 plus 50 which is 530 rupees.

Before the transaction I was having 500 rupees, now I am having assets worth 530 rupees. So, I will go for this transaction. So, the willingness to pay is an indication of the value of the good for the buyer and a buyer is only willing to pay to that level which is equal to the value of the good. If the price goes even a single paise above the value of the good, the buyer will not purchase that good. So, the willingness to pay is a very good indication of the value of the good in the eyes of the buyer.

Now, we can look at it with an example. Suppose, there is a cake that is available in the market and we have 5 potential buyers and these buyers are having different values for this cake probably because they are having different levels of hunger. So, we have a person named Ram, who is very hungry and he is very fond of cakes. So, he puts a value of the cake to be 100 rupees which means that the willingness would be that he would not pay above 100 rupees.

Well, if the price of the cake is 101 rupee and the value is 100 rupees, then why would Ram have this cake? It would decrease the total assets that he would be having. So, in this case the value of the cake 100 rupees tells that Ram is not going to pay above 100 rupees.

Shyam has a value of 80 rupees. So, he will not pay above 80 rupees. Sita puts a value of 70 rupees. So, she will not pay about 70 rupees. Similarly, Gita is putting a value of 30 rupees which means that in the eyes of Gita she should only be willing to pay less than or equal to 30 rupees which is she would not pay above 30 rupees.

Meera is putting a value of 20 rupees. Now, in this example what we are observing is that it is the same cake, but then different people are putting different values to that cake, depending on what they are fond of or what is their current state if they are hungry or not. Now, if there is somebody who is averse to, say, sweet things it is possible that in this case Meera only likes salty items which is why she is not putting a high value on this cake.

Or probably Meera just finished off with her lunch and she is feeling completely satiated. Now, because of this satiety she is not feeling any more hunger. So, she does not want to eat anything. So, in that case the value of the cake would be lesser in the eyes of Meera as compared to the value of the cake in the eyes of Ram.

Now, this value can also help us determine what will be the demand scheduled. So, suppose this

cake is available for more than 100 rupees, probably this cake has a price of 110 rupees. Now, in this case will any of these persons be willing to pay for this particular cake? So, the price is rupees 110. Now, will Ram pay for it? Will Ram, seeing that the value of the cake is 100 rupees, will he be paying 110 rupees? The answer is no. What about Shyam, Sita, Gita and Meera?

They also put the value of the cake to be less than 110 rupees. So, in this case none of these people are going to purchase the cake which means that if the price is more than 100, then the number of buyers who are willing to pay the price for the cake are 0. So, the quantity demanded is 0. So, at the price of greater than 100, the quantity demanded is 0. What about if the price is between 80 and 100 rupees? Now, suppose the price is 90 rupees. Now, at 90 rupees, who is going to buy this cake? Now, Ram puts a value of 100 rupees to this particular cake. Now, if the value of the cake in the eyes of Ram is 100 rupees and this cake is available for just 90 rupees, then probably Ram is going to purchase this cake because if he purchases this cake.

Then he is adding 10 rupees to the total assets that he has; which means that the amount of money that he will have will be less by 90 rupees because he is paying 90 rupees for the cake, but he is getting a cake that is worth 100 rupees in his eyes. So, in that case if he purchases this cake then the total assets of Ram will increase. So, in that case if the price is 90 rupees, then probably Ram is going to purchase this cake. So, at any price between 80 and 100 rupees because 80 rupees is the value that Shyam is putting.

So, if it is anything that is more than 80, say 80 rupees and 1 paise to 100 rupees then we will have only Ram who is willing to pay the price for the cake and so, the quantity demanded in this case becomes 1. For a price between 70 and 80 rupees, say the price is 75 rupees. Now, at 75 rupees Sita will not want to buy this cake.

Why? Because the value in the eyes of Sita is just 70 rupees, so, why should she pay 75 rupees? Similarly, Gita will not purchase the cake for 75 rupees. Gita will also not purchase, but Shyam will think that ok the value of the cake in my eyes is 80 rupees, it is available for 75 rupees. So, if I purchase this cake for 75 rupees I will add 5 rupees to the total assets that I have. Now, remember that in the case of economics we think that everybody is a rational thinker.

So, everybody is making rational decisions to maximize his or her own assets or in other words his or her own welfare. Now, in this case Shyam will think that if I purchase this cake I will add 5 rupees to my assets because just by paying 75 rupees I am getting something that is worth 80 rupees.

So, for any price between 70 and 80 rupees we will have Ram and Shyam who are ready to buy. So, between a price of 70 to 80 rupees we have Ram and Shyam who are willing to pay the price for the cake and so, the quantity demanded becomes 2. Similarly, at a price between 30 and 70 rupees between 30 and 70.

We will have that the price is less than the value that Ram, Shyam or Sita put to it. So, for a value between 30 and 70 Ram, Shyam and Sita will be willing to pay the price for the cake and so, the quantitative demanded becomes 3. Between a price of 20 and 30 rupees we will have 4 people who will be ready to pay the price and so, the quantity demanded becomes 4. And, for a price that is less than 20 rupees all 5 of them would want to pay for it.

So, they will be willing to pay the price for the cake and so, the quantity demanded becomes 5.

So, in this way we can convert the valuation of different buyers into the demand schedule. Now, the demand schedule is the table that tells us what is the quantity demanded at each price. Now, in this case we are observing that when the price goes down, the number of buyers or the potential buyers increases.

And, we can convert this into a demand curve if we plot it. So, here we were observing that above 100 rupees the quantity demanded is 0. So, if the price of the cake becomes more than 100, then the quantity demanded becomes 0. So, which is why we are getting a line, this vertical line here.

Between a price of 80 to 100 rupees you have quantity demanded is equal to 1. So, between 80 to 100 rupees you have only 1 quantity that is demanded. So, which is why we are getting this section. Now, of course, we join both of these together to make it a complete graph. So, between so, if you have more than 100 rupees it is 0 between 80 to 100 it is 1. Then from 70 to 80 it becomes 2. So, 70 to 80; so, this is 70, this is 80. So, between 70 to 80 you have the quantity demanded is equal to 2.

So, we are reaching this point. So, this is the price point of 70. So, here we have 70 and this point is 80 here. So, between 70 and 80 we have a quantity demanded that is 2, then from 30 to 70 it is 3. So, from 30, so, 30 is this point this is 30. So, between 30 and 70 we have a quantity that is 3, between 20 and 30 it is 4.

So, from 20 to 34 are demanded and less than 20 we have a quantity demanded of 5. So, if it becomes less than 20, then there is a demand of 5. So, this is bringing us to the demand curve. So, let us remove these lines now. So, this is now the demand curve that we are observing here.

Now, you will observe here that as the price reduces, the quantity demanded increases which is the law of demand; with a decrease in price there is an increase in the quantity demanded. And, we are observing that this demand curve is coming from the valuation that different people are putting and when the price becomes very less, then the price becomes lucrative for all those people who were putting a valuation above that price. So, the quantity demanded increases.

But, when the price increases then it might reach a level where there are a number of potential buyers who are now thinking that the price is too high and so, they will not demand the good at that particular price. So, as price increases the quantity demanded decreases which is what we are observing in this curve.

Now, with this curve we can start to talk about the consumer surplus which is there at different prices. Now, what is consumer surplus consumer surplus is the difference between the value of the good and the price that a person is willing to pay for it. So, at different price points we can compute the consumer surplus.

Suppose we talk about the price point of 90 rupees. Now, at a price point of 90 rupees there is only one person who is demanding the good which is Ram. Now, Ram has put a value of 100 rupees for the cake and the value is 100 rupees, it is available for 90 rupees. So, what is the consumer surplus for Ram?

It is the value that he had put which is 100 rupees minus the price that he gets to be in the market which is 90 rupees. So, what we are observing here is that the value of cake for Ram is rupees 100 the price at which cake is available is rupees 90 and so, the consumer surplus for Ram is 100

minus 90 is 10 rupees.

So, here we are observing that for at the price point of 90 rupees Ram's consumer surplus is 10 rupees. Now, if the price lowers, suppose in the market this cake is available for 80 rupees. In that case Ram's consumer surplus will be 100 minus 80 is 20 rupees.

If the price goes down even further at a price point of 70 rupees Ram's consumer surplus will be given by the value that he had put 100 rupees minus 70 rupees is 30 rupees. But, at the price point of 70 rupees we also start to observe Shyam's consumer surplus.

So, Shyam's consumer surplus because he had put a value of the cake to be 80 rupees and it is available for 70 rupees, so, Shyam's consumer surplus is this difference 80 minus 70 which is 10 rupees and in that case the total consumer surplus will be given by Ram's consumer surplus and Shyam's consumer surplus is 30 plus 10 is 40 rupees.

Now, remember that in the case of a market everybody is a price taker which means that they are not able to influence the prices, neither Ram can influence the price nor Shyam can influence the price. So, we are not talking about haggling or bargaining in the market.

So, the price is fixed and at this price point, any buyer can purchase any number of items that are there in the market. So, at the price point of 70 rupees Ram can also purchase a cake and Shyam can also purchase a cake because of which we are adding both of these consumer surpluses to get the total consumer surplus. Because at 70 rupees Ram will get a consumer surplus of 30 rupees if he buys the cake, Shyam will get a consumer surplus of 10 rupees if he buys a cake.

And, both are able to buy a cake in this market because the number of goods is not limited and so, the total consumer surplus will come to be 40 rupees. If the price goes down even further; so, say at a price point of 30 rupees we will have Ram's consumer surplus which is given by this area which is the difference between 100 rupees which was his valuation and the price of 30 rupees. So, Ram's consumer surplus here is 70 rupees; Shyam's consumer surplus is 80 minus 30 is 50 rupees.

Sita's consumer surplus is 70 minus 30 is 40 rupees. So, at the price point of 30 rupees, now three people are demanding the goods and all three of them are having different consumer surpluses and the total surplus is given by 70 plus 50 plus 40 is 160 rupees. If the price goes down even further, say at 20 rupees.

Now 4 people are having consumer surpluses. So, Ram's consumer surplus is 100 minus 20 is 80, Shyam's is 80 minus 20 is 60; Sita's is 70 minus 20 it is 50 and Gita's is 30 minus 20 which is 10 rupees and the total surplus is given by 80 plus 60 plus 50 plus 10 which is 200 rupees.

So, now, the total consumer surplus is 200 rupees. When the price goes down even further, say at a price point of 0 rupees, we will have a consumer surplus by all five of the potential buyers. So, Ram's consumer surplus will be 100 minus 0 is 100 rupees; Shyam's consumer surplus is 80 minus 0 is 80 rupees; Sita's is 70 minus 0 is 70 rupees; Gita's is 30 minus 0 is 30 rupees and Meera's is 20 minus 0 is 20 rupees. And, the total consumer surplus is the sum of all of these.

So, 100 plus 80 plus 70 plus 30 plus 20 is 300 rupees. So, what we are observing here is that the total consumer surplus is the area between the demand curve and the price. So, the price is fixed and the area between the demand curve and the price is giving us the consumer surplus.

Now, in the case of a market there are not just 5 sellers there are n number of sellers. And, in the

case of a very large number of buyers and sellers which is our theoretical construct of a competitive market, what happens is that because we have an infinite number of buyers and each buyer is putting a different value to the good. So, these steps will become even finer. And, so, ultimately we will get to a curve that is just a straight line.

So, what is happening in this case is that when the number of buyers is less we are observing this sort of a demand curve. When the number of buyers increases in the market we will start observing a curve like this. Then when the number of buyers increases even further, we will start to observe an even finer curve say something like this. So, as the number of buyers is increasing the demand curve is becoming more and more finer and ultimately when the number of buyers is too high.

It is close to infinity then we will observe just a straight line. So, the straight line that we are so accustomed to watching in terms of the demand curve is actually this demand schedule of a very large number of buyers seen together. So, because of that it has become so fine that it now looks like a straight line. So, now, the demand curve is looking like a straight line. Now, what happens for such a demand curve is that, if we can consider a consumer or a potential buyer at this price point.

So, this is the price that he is willing to pay and this is the price that he is actually getting in the market. So, the difference between both of these is his consumer surplus for this buyer. Similarly, for this buyer we will have a consumer surplus which is equal to this amount.

And if we look at all of these potential buyers we will find that the total consumer surplus is this area that is shown in yellow. So, the total consumer surplus is the area between the demand curve and the price which is the area below the demand curve till you reach the price at which this particular good is available in the market.

Another key takeaway is that with lower prices, we can raise the consumer surplus because here we have observed that; when the prices are high then the total consumer surplus is less. When the price goes down the total consumer surplus increases because the total consumer surplus is this area between the demand curve and the price point.

So, if you bring the price lower, then you will add to the area that is there in the consumer surplus. So, at this price point we have this area in blue that is the consumer surplus because it is the area between the demand curve and the price. At a lower price point we have a larger area which is given by this.

All of this is now a part of the consumer surplus. So, it includes this area that was there earlier plus this area that is there in green. So, at a lower price point the consumer surplus increases. If you reduce the price even further the consumer surplus will increase even further and at a price point of 0 rupees the all the area that is below the demand curve will become the consumer surplus. So, these are the 2 key takeaways: one, total consumer surplus is the area between the demand curve and the price and; two - lower prices raise the consumer surplus. Now it is important to note here that the consumer surplus measures the benefits to the buyers as they themselves perceive it, that is nobody is telling the buyer that this is your consumer surplus.

But, what is happening is that every buyer is putting a different value to the same good, probably because they are in a different profession, probably because they are in a different state, probably

because there is a different level of emergency to all of these people. A person who is extremely hungry will be in a more emergent requirement of food than say a person who just had his meal. So, different people are putting different values.

So, they are perceiving different values and the difference between their values and the price is giving us the consumer surplus. So, it is the measure of the benefits to the buyers as they themselves perceive it. There is nobody from outside who is telling them that this is the benefit that they have, the benefit that they are perceiving is the consumer surplus.

Now, another question that we can ask in the market is why does the seller sell? Now, a buyer was buying things because he was increasing his assets because he was giving less amount of money and he was getting something that was worth more in his eyes. So, which is why, a buyer was buying a good.

Now, the question is why does the seller sell the goods? Now, in the case of a free market, everybody's working for his or her own welfare which means that when the seller is selling the goods probably the seller is also increasing his or her own assets. So, when the seller is selling this pen for 20 rupees, then probably he was able to make this pen for 15 rupees So, that he is able to get a profit of 5 rupees. It is only then that the seller would be willing to sell in this particular market.

Now, in a market, different goods have different costs for sellers. Now, why should any goods have different costs for different sellers and why should different goods have different costs? Well, one primary thing that determines the cost to the sellers is the cost that it takes to manufacture the product that is not just the cost of the raw materials.

And the cost of labor or the cost of running the machines, but also the cost of transportation. Now, there are certain items that are simple to construct or simple to make such as things like potatoes. Now, in the case of potatoes the price is less because the cost of production is less.

On the other hand, if we talk about an expensive item such as a mobile phone. So, a mobile phone requires a much greater amount of technology, it requires resources that might not even be available in the country of manufacturing. So, probably it would require certain rare earth metals that are extracted from certain parts of the earth brought to the place where the phone is going to be manufactured and then say processed or integrated into the device to make the mobile phone. In that case the cost to make the mobile phone will be much greater. At the same time, the same goods can be made by different sellers at different costs because different sellers would be having different efficiencies. A good example is two farmers who are cultivating potatoes, but one farmer is more efficient.

So, he is able to grow more potatoes or more kgs of potatoes per season as compared to the other farmer. So, this brings us to the point that different goods have different costs for the sellers and these goods are sold at different prices. Now, cost is something that is being determined by the product as well as the efficiency of the manufacturer or the seller; whereas, the prices are determined not just by the sellers, but also by the buyers.

To give an example, if there is a particular food fad for say potatoes then the price of potatoes may go up; on the other hand, if there is a food fad that potatoes are bad for health then the prices may also go down. This would depend not just on the cost of manufacturing or on the sellers, but

at the same time it will also depend on the demand for the goods in question. Now, if the price of a good is greater than its cost the seller may sell the good and enhance his or her surplus.

Here there are 2 things that are important, one is the price and the second is the cost. So, there are different costs, there are different prices and if the price is greater than the cost then the seller may sell the goods and enhance his or her surplus or we may even say that it is enough that the seller would enhance his or her own profit or assets.

If this pen can be manufactured for 15 rupees, that is the cost to the seller; if this pen can be sold for 20 rupees, that is the price of the pen. So, if the price is greater than the cost of manufacturing or the cost to the seller, then if the seller is able to sell this pen then he would add 5 rupees to his surplus which is 20 minus 15.

The cost is the value of everything a seller must give up to produce the good and the producer surplus is the amount a seller is paid for the good minus the seller's cost of providing it. So, the amount that the seller is paid for the good is the price minus the seller's cost of providing the good.

To take an example let us say that the cost of producing a cake by 5 different people. In this case Ram is producing a cake for 100 rupees. So, in this case Ram is a seller who is producing a cake for 100 rupees. Now, if it takes him 100 rupees to manufacture the cake, will he sell it for less than 100? The answer is no, because nobody wants to sell something at a loss and in the case of a market we take this assumption that everybody is trying to maximize his or her welfare or surplus.

In this case because the cost to manufacture for Ram is 100 rupees, he will not sell below 100 rupees. In the case of Shyam, his cost of production is 80 rupees so; he will not sell below 80 rupees. Sita is a third manufacturer. Her cost of manufacturing the cake is 70 rupees, so she will not sell below 70 rupees.

In all these cases what we are observing is that we have different sellers who are out there in the market and they have different costs of production and the cost of production gives us the willingness to sell. So, a seller will only sell something if the price in the market is greater than the cost of production; if the price is less than the cost of production then the willingness is not there. We can use this chart of willingness to reach the supply schedule.

If the price of one cake is more than 100 rupees, then say the price of the cake is 110 rupees. Now, at 110 rupees we will find that Ram is willing because he would not sell below 100 rupees, but he will sell above 100 rupees. So, Ram is willing to supply, Shyam is willing to supply.

Sita is willing to supply, Gita is willing to supply and Meera is willing to supply. So, at a price point which is above 100 rupees which is the maximum cost of producing the cake for any of these five sellers we find that all the five sellers are willing to supply the goods. And, so, we will find that at a price of more than 100 rupees the quantity supplied is 5. At a price point between 80 and 100 rupees so, 80 and 100 rupees, so, we are taking a price point in between both of these.

Let us say that the price point that we are considering now is 90 rupees. Now, at a price point of 90 rupees a Ram will not sell because his willingness is not to sell below 100 rupees. So, 90 becomes less than 100, so Ram will not sell. His cost of production is more than 90 rupees, but

what about the other 4?

The other four will be willing to supply the cake because their cost of production is less than 90 rupees. So, if any of them sell a cake then they will be earning a profit now in this case we will have these four people Shyam, Sita, Gita and Meera who will be willing to supply.

So, at any price point between 80 and 100 rupees we will have 4 people who are willing to supply and so, the quantity supplied to the market is 4. Similarly, at a price point between 70 and 80 at this price point say 75 rupees you will have only three sellers. So, between 70 to 80 you have only three sellers and the quantity supplied is 3.

At a price point between 30 and 70 you will have only 2 sellers; at a price point between 30 and 20 you will have only one seller and at a price point that is below 20 rupees you will find that none of these sellers is willing to supply. So, if it is less than 20 rupees, then you have the quantity supplied which is 0. Now, this is the supply schedule which is telling us the quantity supplied for the good by at different price points. So, this is the supply schedule.

Now, we can convert this supply schedule into a supply curve. So, this is the supply curve. At a price of less than 20 rupees we have 0 quantity that is supplied; at a price point of 20 to 30 you have only one good that is supplied. So, at a price point between 20 rupees and 30 rupees you have 1 cake that is supplied. We are getting this vertical section from here and then we join both of these to get the curve. At a price point between 30 and 70 rupees 30 to 70 you have quantity supplied is 2.

So, here, the quantity supplied is 2 between a price point of 30 and 70 and so on. So, in the case of the supply curve what we are observing is that if the price is increasing more and more quantities are being supplied to the market which is the law of supply as the price increases the quantity supplied also increases.

What we are observing here is that we can convert the cost of production or the willingness of the chart into a supply schedule because any person will only be willing to supply at greater than the cost of making the goods and from the supply schedule we get to the supply curve. And, we are observing that as the price increases more and more sellers become willing to supply the goods and so, the quantity supplied to the market also increases which is the law of supply.

Now in this example we are having only 5 sellers, but then in a natural market situation and especially in a competitive market we have a very large number of buyers and a very large number of sellers. Now, when the number of sellers is very large then this curve becomes even more finer.

What happens is that currently we are observing a curve that goes like. So, our current curve looks like this. Now, if the number of sellers becomes more then we will start to observe a curve that has a finer scale and, especially if the goods are also sold in much finer quantities.

And, if you have an even larger number of sellers, ultimately you will reach a position where this curve will just become a straight line.

Now, in this supply curve we can compute the producer surplus at different prices, that is if we consider any price point, what is the producer surplus for each of these different producers. Now, let us consider a price point of say 25 rupees. Now, at 25 rupees Meera's producer surplus is 5 rupees because her cost of production was 20 rupees and the price she is getting in the market is

25. So, her producer surplus is 25 minus 20 is 5 rupees and that is also the total producer surplus. Because the producer surplus of everybody else is 0 rupees because their cost of production is more than 25. Now, at a higher price point of say 30 rupees, Meera's producer surplus is 10 rupees because her cost of production is 20. So, 30 minus 20 is 10 rupees and that is the total producer surplus because here again everybody else is producing at equal to or greater than 30 rupees. If we increase the price even further, say at 70 rupees.

Meera's producer surplus is given by this price minus her cost of production. So, 70 minus 20 is 50 rupees. Gita's producer surplus is 70 minus 30; her cost of production which is now giving a produces surplus of 40 rupees. Sita's producer surplus is 0 rupees because her cost of production is 70 and for others the cost of production is greater than 70. So, in this case what is the total producer surplus? It is 50 plus 40 plus 0 plus 0 plus 0. So, it becomes 90 rupees.

At an even greater price point of say 80 rupees Meera's producer surplus becomes 80 minus 20 is 60; Gita's becomes 80 minus 30 is 50; Sita's producer surplus is 80 minus 70 is 10 rupees; Shyam's is 0 because his cost of production itself is 80 rupees and Ram's is also 0 because his cost of production is greater than 80 rupees. So, he is as good as he is not there in the market. Now, in this case the total producer surplus becomes 60 plus 50, 110 plus 10 is 120 rupees.

If you increase the price even further say at a price point of 100 rupees we find Meera's producer surplus is 100 minus 20 is 80; Gita's is 100 minus 30 is 70; Sita's is 100 minus 70 is 30; Shyam's is 100 minus 80 is 20; Ram's producer surplus is 0 rupees because his cost of production itself is 100.

In this case, the total producer surplus becomes 80 plus 70 plus 30 plus 20 is 200 rupees. And, if the price becomes say 100 and 20 rupees then here you have Meera's producer surplus is 120 minus 20 is 100; Gita's is 120 minus 30 is 90; Sita's is 120 minus 70 is 50; Shyam's is 120 minus 80 is 40 and Ram's is 120 minus 100 is 20 rupees.

Now, we had seen before that if the price goes beyond 100 rupees. Then all 5 stealers are willing to supply the goods into the market and this is what we are observing here. We are having a producer surplus for all five of the sellers and the total producer surplus now has become 300 rupees.

What are the key takeaways from this? 1 - total producer surplus is the area between the supply curve and the price. So, if we consider any of these, this is the supply curve, this is the price and the area that is between both of these, is giving us the producer surplus. Here we were considering only 5 sellers.

If the number of sellers is very large in that case you will find that the supply curve is now tending towards a straight line. And, now the producer surplus is this area that is between the supply curve and the price because for any producer, if this is the price and this is the cost of production then this difference between the price and the cost of production gives us the producer surplus. So, this is the producer surplus for a seller who is at this point.

For a seller who is at say this point, the producer surplus will be given by this amount and so on. So, in total when you have a very large number of sellers, then the producer surplus is this area. So, this is the first key take away point. The total producer surplus is the area between the supply curve and the price.

The second is that higher prices raise the producer surplus which is what we had seen before. For a very low price point say 25 rupees total producer surplus is 5. When the price increases we observe that the producer surplus goes on increasing. So, in these curves you will observe that as we increase the price as the pen curve moves up, we start seeing a larger producer surplus. This is the second key takeaway - higher prices raise the producer surplus.

And, in this curve what we observe is that at this price point, this is the producer surplus; at this price point we have not only this blue area, but this green area is also added to it; at this price point we have the blue, green and the pink areas. This total becomes the producer surplus, that is this triangle. This triangle is now telling us the producer surplus. If the price increases even further then we will even add this yellow area. So, as the price increases the producer surplus also increases.

And, the third key takeaway is that producer surplus is measuring the benefits to the sellers as they themselves perceive it. Why is that so? Because each seller has a particular cost of taking the good, a cost of providing it to the market and if the price point is greater than this cost of providing the good to the market, then the seller would himself or herself perceive that if I sell this good to the market at the prevailing price point, then I am going to earn a profit.

That is, I am going to increase the assets that I have, I am going to increase the welfare with me that is the producer surplus. Now, this decision is being made by the seller himself or herself. There is no third party who is telling the seller that you should sell this good at this price point because this much is your benefit. No, the seller is himself or herself making a judgment, looking at the prevailing market condition and looking at his or her own cost of production, to maximize his or her own welfare.

As we had seen before in the case of economics we assume that people are rational decision makers and in this case people are making a rational decision to sell or not to sell at any given price point based on what is their cost of providing the goods. And, this is a decision that everybody is making by themselves, not by any third party. So, in this case the producer surplus measures the benefits to the sellers as they themselves perceive it, not anybody else.

In this way we can say that to summarize total consumer surplus is the area between the demand curve and the price; lower prices raise the consumer surplus and consumer surplus measures the benefits to buyers as they themselves perceive it. That is, if we look at a market equilibrium, so, here you have the price, here you have the quantity and here we have the supply curve and here we have the demand curve. This is the equilibrium price. At this price the consumer surplus is given by this area.

The total producer surplus is the area between the supply curve and the price. Higher prices raise the producer surplus and producer surplus measures the benefits to the sellers as they themselves perceive it. That is to say in the case of this market equilibrium the producer surplus is given by this area that is between the price which is given by this line and the supply curve. So, this is how the surplus works in the market. That is all for today. Thank you for your attention. Jai Hind!

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Module 7
Markets, Welfare and Conservation
Lecture 2
Cost of taxation

Namaste! We carry forward our discussion on markets, welfare and conservation and in this lecture, we will have a look at market efficiency and the cost of taxation. So, let us begin by summarizing what we had seen in the previous lecture. We had observed that total consumer surplus is the area between the demand curve and the price. That is the consumer surplus is the area between the demand curve and the price. So, this yellow colored area is the consumer surplus. Lower prices raise the consumer surplus, because when the prices become less so, when you draw a line, say here, so in that case the yellow triangle will extend to this area and so, the consumer surplus would increase. So, lower prices raise the consumer surplus and consumer surplus measures the benefits to buyers as they themselves perceive this is because the consumer surplus is measuring the difference between the value of a good to a buyer and the price that the buyer has to pay to get that good.

So, if I as a buyer have put a value of 50 rupees to this pen and if this pen is available to me for 20 rupees, so this difference of 50 rupees minus 20 rupees which is 30 rupees is my consumer surplus. It is the surplus that I am getting, because in my eyes this good has a greater value and I am able to get it at a lower price. So, the buyer himself or herself is perceiving the value.

And, because this is a value that is perceived by the buyer so the consumer surplus measures the surplus to the buyer as they themselves perceive. Then we observe that total producer surplus is the area between the supply curve and the price, that is if you look at this curve the green colored triangle is the area between the supply curve shown here and the price. So, this is the producer surplus.

Higher prices raise the producer surplus. So, if the price in place of this much, if it raised this much then the triangle would become from here to here. So, this large triangle so, the producer surplus increases when the price increases and third we observe that producer surplus measures the benefits to the sellers as they themselves perceive it, because what the producer surplus is measuring is the difference between the price of the good and the cost that they takes to make that good or to provide that good.

In the example of this pen the price of the pen was 20 rupees, but if the producer was able to make it and provided for just 10 rupees. So, the difference between 20 rupees minus 10 rupees is 10 rupees is the producer surplus or in other words, the profit that the producer is getting.

Now, the cost to the producer is something that is to a large extent in his or her own hands, because the producer might go for a cheaper variety of plastic and reduce cost or the producer might go for a more efficient machine to make this pen and reduce the cost. Now, the difference between the price and the cost to the producer is what is the producer surplus as they are themselves perceived. So, this is the summary of what we have seen so far.

Now, with both of these we can define the total surplus. Now, in a market people are either buyers or they are sellers. If we add the buyer surplus and the seller's surplus that is the consumer surplus and the producer's surplus then we come to a value of the total surplus. So, total surplus is defined as the consumer surplus plus the producer surplus and as we have observed consumer surplus is the value to the buyers minus the amount paid by the buyers.

Now, the amount paid by the buyers is the price of the goods. So, consumer surplus is the value to the buyers minus the price. The producer surplus is the amount received by the sellers which is again the price minus the cost to the sellers. So, if you look at this graph then we have a consumer surplus in yellow, the producer surplus in green, if we add both of these together we will get the total surplus.

Now, the total surplus we can write as consumer surplus plus producer surplus. Consumer surplus is value to buyers minus amount paid by the buyers and the producer surplus is amount received by the sellers minus cost to the sellers. Now, in this case we can rearrange the terms on the right hand side to say that to the buyers minus cost to the sellers plus amount received by the sellers minus amount paid by the buyers.

As we have seen before the amount received by the sellers is the price, the amount paid by the buyers is also the price. So, we are subtracting price from price. So, the amount received by the sellers is the same as the amount paid by the buyers.

So, we can cancel out both of these. We can cancel this and we can cancel this and so, in that case the total surplus becomes the value to the buyers minus the cost to the sellers. This is the total surplus value to the buyers minus cost to the sellers and an objective of planning is to maximize this total surplus, why; because everybody in the market is either a buyer or a seller.

Now, if we do not want to discriminate between buyers and sellers suppose, we were on the side of the buyers only then we would have said that ok let us increase the buyers surplus or the consumer surplus by reducing the price, but when we reduce the price then it would affect the producer surplus, because when the price reduces the producer surplus reduces.

So, if we act only on the side of the buyers then it will hurt the producers. On the other hand, if we act only on the side of the producers then we would say that let us increase the price so that the producer surplus increases, but when the price increases the consumer surplus would decrease, because the buyers will have to pay a higher price.

So, an increase in the producer surplus would lead to a decrease in the consumer surplus, but if we do not take anybody's side, we are not on the side of the buyers, we are not on the side of the producers, but we are on both of their sides then what we will say is ok let us see if we can increase the the buyers and the producers surplus what is the maximum that we can get?

That is a maximization of the total surplus and that is an objective of planning. We aim to plan in such a way that the benefit to everyone is maximized. We are trying to maximize everyone's ben-

efit whether he or she is a buyer or a seller.

We have seen that total surplus is value to the buyers minus cost to the sellers and since surplus is the benefit to the buyers and sellers as they themselves perceive it the aim should be we have to maximize the total surplus which means that we should maximize the value to the buyers and we should minimize the cost to the sellers. In that case the total surplus will be maximized.

We can do that by ensuring that goods should reach those buyers who value it the most and come from those sellers who take the minimum cost to produce them which means that if there are two buyers and one is putting a cost a value of this pen to be say 50 rupees and the other one is putting the value to be say 100 rupees.

What we are saying here is that the value to buyer 1 is 100 rupees and the value to buyer 2 is 50 rupees. Now, if this pen is available for a price of 20 rupees then in that case the surplus for buyer 1 is 100 minus 20 is 80 rupees and the surplus for buyer 2 is 50 minus 20 is 30 rupees.

Now, if the aim of planning was to maximize the surplus then we would want this pen to go to buyer 1, because if it goes to buyer 1 then the total surplus from the viewpoint of the buyers it increases by 80 rupees whereas, if it goes to the second buyer the total surplus from the point of view of the buyers, it increases only by 30 rupees.

If we are trying to maximize the total surplus we should work in a way that the value to the buyers is maximized, that is the goods should reach those buyers who value it the most. At the same time it should come from those sellers to take the minimum cost to produce them, because in this equation when the cost to the sellers is reduced then the total surplus increases and that is what the objective of planning should be.

So, in the case of proper planning we are trying to maximize the surplus of the society, we are trying to maximize the buyers as well as the seller's surplus or the producer as well as consumer surplus and in that case what we are saying is that we should produce more and more of those goods that have a higher value and these goods should go to those people who value it them the most, because in that case the buyers surplus would be or the consumer surplus will be maximized.

At the same time we should try to produce goods in a way that it is less costly to produce. So, the cost to sellers should be minimized as far as possible, because when that is done then the producer surplus increases and in the market the goods should come from those sellers that are able to produce the goods at the minimum cost.

When a good is manufactured at the minimum cost and is going to a buyer who values it the most in that case the total surplus is maximized or in other words what we are saying is that say the value to buyer 1 is rupees 100, the value to buyer 2 is rupees 30 the the cost to make the cost for seller 1 is say rupees 10 and the cost to seller 2 is rupees 15.

In this case if the good goes to buyer 1 and comes from seller 1, what we are saying is the good is going from seller 1 to buyer 1 so in that case, because the seller 1 has the minimum cost and the buyer 1 has the maximum value then the total surplus is 100 minus 10 is 90 rupees, but in other cases if it goes from seller 1 to buyer 2 so in that case the surplus becomes 30 minus 10 is 20 rupees.

If the goods go from seller 2 to buyer 1 so, for seller two it costs 15 rupees to produce so, the to-

tal surplus is 100 minus 15 is 85 and when it goes from seller 2 to buyer 2 then the total surplus is 30 minus 15 is 15 rupees.

What we are observing here is that the total surplus is a maximum of 90 rupees when it goes from seller 1 to buyer 1. Now, in this case seller 1 is the one with the minimum cost of production and buyer 1 is the one that has the maximum value for goods. So, in this situation the total surplus of the buyer and the seller together is maximized to 90 rupees. In other cases the total surplus is just 20 rupees or 85 rupees or 15 rupees.

So, to maximize the total surplus the goods should reach those buyers who value it the most and should come from those sellers who take the minimum cost to produce them, in that case the total surplus maximized and that is one aim of planning to maximize the total surplus or the value of the society and this brings us to the point of efficiency. Efficiency is the property of a resource allocation of maximizing the total surplus that is received by all members of the society. So, we will say that the market is working efficiently when it is allocating resources in such a manner that the total surplus is maximum and we have seen that the total surplus is maximum when goods go from the sellers that take the minimum cost to produce them to the buyers who value them the most, in that case the total surplus is maximized and then we say that the market is working on an efficient manner.

In the case of a normal market equilibrium the total surplus is maximized at the equilibrium. Now, why is that so? So, here we have the demand curve and the supply curve and this is the equilibrium point. So, at equilibrium point this is the price that the market will charge for this good and this is the equilibrium quantity that is demanded or supplied. Now, the question is is this the maximum where the or is this the point where the total surplus is maximized or not? To prove that let us look at points to the right and to the left of the equilibrium.

If we consider a point here, now at this point so this is our equilibrium quantity, this is a quantity that we are checking and this is another quantity that we are checking Q 1 and Q 2. Now, at point Q 1, the seller is able to supply at this cost and the value to the buyer is this much, so at any point to the left of the equilibrium so it is this point Q 1, the value to the buyer which is this is greater than the cost to the seller which is this.

Thus, it makes sense for the seller to sell the goods to the buyer and it makes sense for the buyer to buy it from the seller at some price that will benefit them both. Suppose they choose a price, say somewhere here and at this price so we are not talking about the equilibrium price.

But we are saying that at any mutually agreeable price that any price between this point and this point if the buyer and the seller make the transaction, that is the buyer buys the goods from the seller in that case both of them will be benefited, both of them will increase their surplus.

And so, if we let the market remain at this point where the transaction is not happening then this is not a point where the surplus is maximized or in other words what we are saying is that if we keep the market at a point that is to the left of the natural equilibrium then there is still a scope of increasing the welfare.

Now, remember that we are trying to find out the point where the total surplus is maximum and what we are observing is that to the left of the natural equilibrium there is still a scope to increase the maximum surplus or the total surplus by undergoing a transaction at any mutually

agreeable price.

If there is a scope to increase total surplus it means that it is not a point where the total surplus is maximum. So, it is telling us that at all the points to the left of the equilibrium, the total surplus is not maximum whereas, if we take any point to the right. So, we are considering this point Q 2. At this quantity the value to the buyer is this and the cost to the seller is this. So, it costs more to the seller and the buyer values it less. Now, at any such point to the right from the equilibrium, the value to the buyer is less than the cost to the seller thus, it does not make any sense for the seller to sell the good and the buyer to buy it at any mutually agreeable price.

What we are saying is that any point to the left of the equilibrium is not optimum and any point to the right of the equilibrium is also not optimum and the more we shift to the left or the more we shift to the right the greater is the possibility that we are moving away from the maximum.

If at any point to the left or to the right of the equilibrium point, the total surplus is not maximum then that would mean that at the equilibrium point the total surplus is maximum which means that in planning when we were trying to maximize the total surplus then we should aim to reach the point of the national equilibrium that is determined by the point of intersection of the demand in the supply curves.

What we are saying is that the total surplus is maximum at the equilibrium and this is what we should be aiming at during the planning process. So, total surplus is maximum at equilibrium. With this understanding, let us now try to explore the cost of track of taxation.

We have seen before that for the proper functioning of the market government is required, because the market cannot function well if we do not have the right of property and if you do not have a rule of law in which whenever there is a violation of the right of property then it is acted upon by institutions such as the police and the judiciary.

Now, when we say that for the functioning of the market we require these things; the right of property and these institutions then these institutions and these rights or the making of these rights they also entail a cost, because when we talk about the right to property then we need legislators to give this right or who enact a legislation that provides this right to the people and we require the institutions such as police and the judiciary to uphold this right.

Now, the people who work to make these legislations or the people who work to enforce these legislations also need to be given certain remuneration for their work. So, the government requires certain money to run its own operations to maintain legislatures, judiciary and executor. Now, where will the government get money for these operations?

One way out is through taxation. So, the government imposes a taxation on people or on certain transactions to raise money for its own operations and those operations are crucial for the working of the market. Another thing that we will look throughout this course is that in certain cases the government is also required to improve upon the market outcomes.

Now, those might entail a further cost. So, for instance if as we have observed in the case of externalities, if smoking imposes an externality on the society then it has to be reduced. Now, to reduce the externality the government may act to internalize the externality by, say taxing the cigarettes.

Now, this sort of a thought process planning and execution will also end in certain costs. So, all

of these costs or a majority of these costs are met through the taxation process. So, the taxation can be either to provide revenue to the government for its own workings or it can be to incentivize or to disincentivize certain activities so that the surplus of the society is maximized.

To bring the market to a point where the society's total surplus is maximized, not that of just some buyers or just some sellers alone, which is why taxation is needed, but then taxation also imposes certain costs, so, before we look at the cost of taxation let us summarize what we have seen before.

The taxation can be imposed on a seller. In this case the government may say that ok whenever the seller makes or sells a good then the seller will be taxed. Say the government says that for every pen that the seller sells, the seller will have to pay 50 paise of tax.

The thing is when the seller is taxed and only the seller then the cost of making the good increases, because you have to pay a certain share of the tax also which will be included into the cost of the good and if the cost of a good increases then the supply curve shifts to the left. So, this is the original supply curve and this is the supply curve with the taxation. So, it shifts to the left.

Earlier the equilibrium was at this point and now the equilibrium has shifted to this point where the red curve, the new supply curve, and the demand curve interface. So, this is the equilibrium without the tax and this is the equilibrium with the tax. Earlier this was the price without the tax, the price that the buyers were paying and the price that the sellers were getting.

But now when we have shifted it to the left then the buyers are paying this price and the sellers are getting the price that is given by this vertical line intersecting with the supply curve. So, this is the price that the seller starts getting and the difference between the price that the buyers are paying and the price that the sellers are getting is the amount of taxation that has been imposed by the government.

When the government says that 50 paise of will be imposed on each sale of the pen then this is 50 paise. Now, out of these 50 paise the sellers are paying a share that is given by the difference between the original price that they were getting and the new price that they are going to and the buyers share is given by the new price that the buyers are paying minus the old price that they were paying.

Which means that even if we have imposed a tax only on the sellers, even then the tax gets distributed between the buyer and the seller. So, that is a key point to remember and the buyer's share is given by this amount and the seller's share is given by this amount.

On the other hand, when a tax is imposed only on the buyer, what the government is saying now is that we are not going to tax the sellers, but whenever the buyer buys this pen, he will have to pay 50 paise. Now, what happens? When the cost of the product increases that will lead to a shift in the demand curve to the left so, this is the original demand curve, this is the new demand.

Now, because the tax is being imposed only on the buyers, we are seeing a shift only in the demand curve and there is no shift in the supply curve. Now, in this case when it shifts this was the earlier equilibrium without the tax, this is the new equilibrium with the tax. Now, in this case what we are obtaining is that the price that the sellers get is this much only where the demand and the supply grows are meeting, but the price that the buyers have to pay is this much, because

they are not only paying the amount to the sellers which is this one, but they are also paying the tax which is this much. So, they are paying not just the seller, but they are also paying the government with the tax. So, this is the price that the buyers pay.

Earlier the buyers were paying only this much, the amount that is given by the normal equilibrium without the tax. In this case the increase of payment for the buyers is this much, the amount that they are paying now and the amount that they were paying without the tax. So, this is the buyer's share. On the other hand, earlier for this much amount the sellers were getting this price, but now they are getting this price.

The seller's share is this much the amount that they were getting before minus the amount that they are getting now. So, with both of these we can understand that whether a tax is imposed on the seller only or on the buyer only the impacts are the same. The tax gets distributed between the buyer and the seller. So, no matter whether the government taxes the buyer or whether it taxes the seller the net result will be the same both will have to pay a particular share.

Whatever be the case this is the net result of the tax. So, this is the normal equilibrium and with the tax if this much is the amount of the tax we can draw a line of the amount, we can shift it to the right to the left of the equilibrium till we reach a point where it touches both the demand curve and the supply curve and that would give us then the new location of the equilibrium line and there will be a buyers share given by this much and there will be a sellers share which is given by this much and the total amount is known as the size of the tax.

So, this is the impact of taxation. Whatever happens, there is a certain amount of money that has to be paid by the buyer and there is a certain share of the tax that has to be paid by the seller. Now, in this situation when the size of the tax is T , we can compute the tax revenue. So, what is the total amount of money that the government gets by imposing this tax that is known as the tax revenue.

The tax revenue is given by the size of the tax multiplied by the quantity that is sold after the tax. So, what we were seeing is that earlier the equilibrium quantity was this, but with the tax the dual equilibrium quantity is this. So, this equilibrium quantity or the number of units of pen that must be getting sold after the tax multiplied by the size of the tax. If one pen is sold and the size of the tax is 50 paise per pen then the government gets the tax revenue of 50 paise.

If two pens are sold then the government gets 50 paise into 2 is 100 paise or 1 rupee and so on. So, the quantum of the tax revenue that is collected is given by the quantity sold multiplied by the size of the tax. Now, the quantity sold is this much. So, we can observe that if we look at the area of this rectangle then it has a width of the quantity sold and it has a height of the size of the tax.

And in that case the area of this rectangle, the pink colored rectangle will give us the tax revenue to the government or the tax collected by the government which is given by Q into T . So, this is the quantum of the tax revenue that gets collected, but this also puts on a new thing.

It brings up a new concept of deadweight losses. So, earlier what we were observing is that in the case of a premarket without a tax, we were having a consumer surplus, we were having a producer surplus, but now we have this new situation. Now, the consumer surplus will now reduce, because the consumer surplus is the value that the consumer was putting on a pen minus the

price of the pen.

So, this much is the consumer surplus of one particular consumer and the total consumer surplus is given by this triangle. Now, because the consumer is now paying a higher price earlier, the consumer was paying a lower price that was given by this amount.

So, this is the price without the tax, but now the buyer has to pay a higher price and we have observed that in the case of the consumer surplus it is the difference between the value of a good and the price that the buyer has to pay. So, if the buyer has to pay a higher price in that case the consumer surplus will reduce which is what we are observing in this case. The consumer surplus is now only this much portion. It is not this triangle that we were having before.

Earlier we were having this big triangle, but now we are having only this small triangle. So, the consumer surplus reduces. What about the producer surplus? Now, the producer surplus also reduces, because the producer surplus is the difference between the price that the producers are getting and the cost of making the goods.

The cost of making the good remains the same, but now they are getting the lower price, because earlier they were getting this price without the tax, but now they are getting this price and because the producer surplus is the price minus the cost of production so now, the line shifts to here earlier we were having this whole area that was the producer surplus, but now we are having only this small triangle that is the producer surplus.

So, with the tax we have a reduction in the consumer surplus and we have a reduction in the producer surplus, but a part of the earlier surplus is going to the government in the form of the tax revenue. So, there is a surplus for the government. So, what is happening now is that earlier the surplus was this whole big triangle which you can see is yellow plus pink plus green plus grey area, yellow, pink, green and the grey area.

That was the earlier total surplus. Now, what is happening is that we have a consumer surplus which is yellow, the government surplus or the tax revenue which is pink and the producer surplus which is green.

So, now, the surplus is equal to yellow plus pink plus green which means that this grey portion that was earlier a part of the surplus is now no longer a part of the total surplus, because this grey portion it is neither a part of the consumer surplus nor a part of the producer surplus nor a part of the tax revenue.

Which means that there is a reduction in the total surplus, there is a fall in the total surplus that is resulting from a market distortion such as taxation. Now, taxation is a form of market distortion, because we are changing or the government is changing the natural outcome or the natural equilibrium of the market.

Earlier the price that the buyers were paying was the price that the sellers were getting, but now there is something in between that is not a part of the natural market equilibrium. It is something that has been imposed by the government.

It is a market distortion and a deadweight loss is the fall in the total surplus which is what we have seen in the form of this grey area, it is a fall in the total surplus that results from a market distortion such as taxation. Now, taxes cause a deadweight loss, because buyers and sellers are prevented from realizing all the gains from the trade.

This loss of surplus does not even approve to the government since trades that become uneconomical due to taxes do not occur at all. What we are saying here is that earlier if we look at a point say this one. So, we are looking at this line.

In this case when the line touches the supply curve, this is the cost to the seller to produce the goods and where this red line is touching the demand curve is this one. So, this is the value that people were putting on this particular good.

So, we have a situation where the value to the buyer is greater than the cost to the seller, but because of taxation it is now no more lucrative for the seller to produce the the good at this quantity at this high cost, because when the seller has to pay the tax then the point with the tax would reach above the demand curve.

This transaction just does not occur in the market, because of the tax. So, this is a transaction that was earlier possible that was earlier benefiting both the buyer and the seller, but because of the taxation this transaction now no longer happens, because it is not beneficial to the buyer and the seller and, because this transaction just does not occur so the government also does not get a revenue out of it, because the government will get a revenue only when the good gets sold.

The revenue is the quantity of goods sold multiplied by the amount of tax, but if the goods are not sold, because it is no more lucrative to the buyer and the seller then the government also does not get the revenue. So, this is a loss in the total surplus that is arising, because of the market distortion in the in this case the taxation.

The deadweight loss or the quantum of the deadweight loss would depend on how elastic or inelastic are the demand and supply. Now, if you remember when we talk about inelastic demand or supply they are represented by curves, but that are more towards the vertical. So, they look very much like the letter I, because they look a bit more vertical. So, when we talk about an inelastic demand and an inelastic supply, it means that when there is a change in the price then there is no change in the quantity demanded or the quantity supplied or there is very little change in the quantity demanded or the quantity supplement.

In such a scenario the deadweight loss; so what we are doing here is that we are keeping the quantum of the tax that is T we are keeping it as fixed. So, this is T and we are keeping this T fixed and we are just changing the demand and the supply according to their inclinations. In the case of an inelastic demand and supply we have a deadweight loss like this.

Now, if we increase or if we change the demand to make it an elastic demand then the deadweight loss is not this curve. Now, if you can see this curve and this curve, it is very easy to see that this deadweight loss, because of an elastic demand is greater than the deadweight loss which was there in the case of an inelastic demand and supply.

Similarly, if we keep the demand curve same, but if we make the supply curve elastic then also we start to observe that the curve that the deadweight losses have increased as compared to this these curves where we have an inelastic demand and supply and if we make demand and supply both elastic then the deadweight loss increases even further.

What we are observing here is that the deadweight losses increase with elasticity. If the demand is, we have a higher deadweight loss, if the supply is elastic we will have higher deadweight loss, if demand and supply are both elastic then we will have a much larger deadweight loss.

This is a result that we are observing that if the quantum of the taxation or the size of the tax is kept the same, but if the elasticity of the demand and supply curve if they are changed then we can observe that the deadweight losses will increase when demand and supply curves become more elastic. So, this is the result that the deadweight losses increase with elasticity.

The next question is how much should be the quantum of the tax size? Should the government have a small tax size or should it have a larger tax size which means that and for the sale of every pen should the government tax say 10 paise, 20 paise, 50 paise, 1 rupee, how does the government decide how much should be the amount of the tax size is what we are now trying to analyze.

If the tax is very small the total tax revenue collection itself is very small. Collected by the government is equal to $Q \times T$ where Q is the quantity of the goods that are bought and sold and T is the tax size. Now, if T is very small as we are observing here. So, in this case this much is T . So, if T is very small then $Q \times T$ also becomes small quantity and so, the tax revenue that is collected by the government as given by this pink colored rectangle the area of the pink colored rectangle it also is small quantity.

If the government increases the value of T that is the government is increasing the tax size. So, now, we have this much of T . This is now the size of T . Now, what happens when the T is increased Q decreases, because with more and more taxation it becomes less and less lucrative for the buyers and the sellers to undergo the transaction.

So, less quantity of goods will be sold in the market which is what we are observing here, when T has increased the Q which is given by this much length it decreases. So, earlier we were having a larger Q , but now we have a much smaller Q . So, Q reduces, but the total tax revenue has increased because this rectangle, the pink colored rectangle, has a smaller area as compared to this rectangle. So, when the T is increased Q reduces, but $Q \times T$ still increases.

Now, if the tax increases even further then we will have a situation like this. So, now, the T has increased even more, the Q has reduced even more and the quantum of tax collected is now given by the area of this pink colored rectangle.

Now, what will happen if the T is increased even further so, now the tax size is very large and the quantity that is bought and sold is very small. So, now Q is only this much and the quantum of the tax collected is given by the area of this pink colored rectangle. What we are observing here is that this rectangle now has very little area.

We started with a small tax size where we had a small tax revenue, then the tax revenue increased when T is increased, then it reaches to a maximum and then it starts to decrease and if you have a very large amount of T then Q will reduce to such an extent that you will have practically a straight line for the rectangle and the area will be very close to 0.

If the tax increases to a value that is too high so in that case the tax collection by the government will be too less, it will be next to 0 which brings us to the Laffer's curve. Now, Laffer's curve says that if we plot the tax size or what we are plotting here is the T and we are plotting T on the X axis and we are plotting tax revenue on the Y axis meaning that on the Y axis we are plotting $Q \times T$.

In this case as T increases $Q \times T$ it increases. What we were observing here was that in the

case of a very small T we were having a smaller value of the tax revenue. When T increases so at a smaller value of T and say this value of t the value of the tax revenue is this much, but when you increase the size of t then the tax revenue is higher.

With increasing T, the Q into T increases then it reaches a maximum then we will have a maxima in this point. At this point we have this is the value of the P that the government should aim for to have the maximum revenue, but if the government increases the tax size even further so if the government increases it from this to even larger amount then the tax revenue that is collected it would again decrease.

So, at this point we have the value of T and this and the value of the tax collected will be now this. So, this is the Laffer's curve. The Laffer's curve shows us that when the government increases the size of T, the revenue collection it increases then it reaches a peak and then it starts to decrease which means that if the government is putting up a tax to maximize its revenue, because the government needs revenue to meet its operational expenses then the tax size should not cross this point.

It should not be anything less than this, it should not be more than this. So, this is the most optimum tax size where the government will earn the maximum amount of revenue from taxation. So, this is the benefit of the Laffer's curve, but another thing also happens at the same value.

Now, if you concentrate on the deadweight losses. So, when the T value is very small then the deadweight loss is given by the area of this triangle in grey color. So, for a very small amount of T, this area is small. When T increases, the area of the grey colored triangle increases. So, the deadweight losses increase.

When T increases even further, the deadweight losses increase even more and for a very large amount of T the deadweight loss is even further more. So, what is happening is that when T increases the deadweight losses it goes on increasing. So, this is not the same as in the case of the Laffer's curve.

In the case of the Laffer's curve when T was increasing the revenue collected by the government increased, reached a maximum and then decreased, but in the case of the deadweight losses they go on increasing which tells us that if the government is aiming for a larger value of T then probably there are deadweight losses will be a bit too much.

Now, deadweight loss is representing a loss from the total surplus. So, earlier we were having a total surplus which is given by the sum of the producer surplus and the consumer surplus. Now, with the taxation this total surplus is now divided into four parts; we have the producer surplus, we have the consumer surplus, we have the tax revenue and we have the deadweight losses.

So, deadweight loss is a loss from the total surplus that accrues neither to the producers nor to the consumers nor to the government and so when we had seen earlier that when we are talking about planning then we should plan in such a way that the total surplus is maximized, but what we are observing here is that with the taxation the total surplus reduces and this loss or this reduction that accrues neither to the government nor to the producer or consumer is the deadweight loss.

And in this curve even though we were saying that this is the the tax size that was the optimum for maximizing the revenue what we observe here is that for this tax size the deadweight losses

are already too substantial which means that if the government has to do a planning and if the government is maximizing its tax revenue then probably it is not a very efficient planning for the society, because the deadweight losses are too high. So, probably the government should aim for a tax size that is less than that.

So, the deadweight losses are a bit less. We will not be able to completely eliminate the deadweight losses, but the government should aim for a deadweight loss that is small enough that can be tolerated by the society. So, the optimum is determined not just by the maxima in the Laffer's curve, but is also determined by the deadweight losses that will happen, because of the taxation distortion that is happening in the market.

With this we can now summarize the learnings of today's lecture. The first is that the tax reduces the total surplus by introducing dividend losses. Total surplus is the sum of the producer surplus and the consumer surplus which means that the area that is below the demand curve and above the supply curve to the left of the equilibrium that is giving us the total surplus and it is distributed between the producers and the consumers.

Now, total surplus is important for planning purposes, because it is not favoring either the producers or the consumers, but when we talk about total surplus we are saying that every person in the society is either a producer or a consumer and in this case we are maximizing the surplus for maximum number of people or for code of the society which is why we are talking about the total surplus.

Now, in the case of the consumers the consumer surplus is the difference between the value for a product or a good and the price that the consumer will have to pay for it. So, if the consumer pays or puts a very high value to a product and it is available cheaply for a lower price then the consumer surplus is large. On the other hand, the producer surplus is the price that the producers get minus the cost of production.

If we increase the price the producers benefit, but at the cost of the consumers, because the producer surplus will increase, but the consumer surplus will go down. If we reduce the price then the consumers will benefit, but at the expense of the producers, because the consumer surplus will increase, but the producer surplus will go down.

But when we talk about the total surplus then we see that the maximum of total surplus is reached at the national equilibrium where the demand and the supply curves meet and why is that so? Because if we consider any point to the left of the equilibrium of the market then we will have certain buyers who are putting a large value to the good.

There are certain sellers who are producing it at a low cost and if there is a transaction between these buyers and the sellers then the total surplus can increase even further which means that any point to the left of the equilibrium is not an efficient position of the market with regards to the total surplus.

Similarly, any point to the right of the equilibrium point, we will have a situation where the cost of production is greater than the value that the consumers put on the good which means that it is again not an efficient point which tells us that the point of natural equilibrium is the most efficient with regards to the total surplus.

So, total surplus is maximized at the normal market equilibrium. Then we observe that when

there is a taxation then it reduces total surplus and the earlier total surplus is now distributed between the producers, the consumers, the government that gets the tax revenue and the deadweight loss that occurs to neither the producer nor the consumer nor the government. The tax revenue to the government is given by Q into T , where T is the size of the tax and Q is the quantity that is transacted in the market that is bought in soon.

Then we observe that as T increases the deadweight losses increases, but when T increases the tax revenue increases, reaches to a maximum then decreases again following the Laffer's curve. We also observed that when we talk about the deadweight losses if there is elasticity then the deadweight losses are blown.

If we consider an inelastic demand and supply for the same tax size the deadweight loss is less, if either the demand or the supply curves become elastic then the deadweight losses are more, if both the demand and supply curves are elastic then the deadweight losses are even more.

The quantum of deadweight losses depend on the elasticity of the demand and supply and the deadweight losses increase with the tax, but government revenues increase and then decrease following the Laffer's curve.

That is all for today. Thank you for your attention. Jai Hind!

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Module 7
Markets, Welfare and Conservation
Lecture 3
International trade

Namaste! We carry forward our discussion on Markets, Welfare and Conservation, and in this lecture we shall explore International Trade. So, what is international trade? International trade is the exchange of capital, goods, and services across international borders or territories.

The key terms are exchanged. In the case of international trade there is an exchange of things which can include capital, it can include goods, and it can include services, but the important thing is that it should occur across international borders or territories.

International trade is the exchange of capital, goods, and services across international borders or territories. And over time, what we have observed is that international trade is growing. If we look at the value of the global exports over time, and in this case we are taking a time series of the value of world exports at constant prices relative to 1913, that is, values corresponding to world global volumes indexed at 1913 is equal to 100.

What we are saying here is that, if 1913 values are taken to be 100, what are the current values and what have been the values over a long period of history. So, this is what we are trying to look at in this particular graph. So, we can observe that in the year 1800 the international trade was very minuscule, but over time it has been growing and currently we are at a level that is around 50 times that of 1913. Which means that in a span of around a 100 years, we have increased in the global trade values or global export values by as much as 50 times.

And the other thing to note from this curve is that earlier the growth was very less, but these days it has been growing at a very fast pace, especially since the end of the Second World War. So, after the Second World War the value of global exports just skyrocketed and today it is a very large value.

If we look at the actual value of exported goods and services, then currently we are around 25 trillion dollars worth of goods and services are being exported every year. And, this export is occurring for a number of different things. The most important things or the lion's share are things like cars or electronic micro circuits or medicaments or gold. So, these are things that are occupying a very large portion of the goods trade.

And these goods are exported from several countries. The biggest exporting country is China and as much as 15 percent of the world's imports are occurring from goods and services that are being exported from China.

The second largest exporter is the United States with a share of 9.2 percent, followed by Germany at 8 percent. So, these are three largest exporters of goods. And the goods are exported to a number of different destinations. Now, if you look at destinations, the United States is importing around 14 percent of the global imports. So, this is the largest export destination. So, a large number of or a large quantity of goods and services are exported to the United States, and the United States is importing these.

The second number is China at 9 percent followed by Germany at 6.2 percent. So, what we are observing here is that, the countries that are the largest export origins are also the biggest export destinations. Which means that, on the world stage there are certain countries that are the biggest exporters as well as the biggest importers.

And, this large volume of trade is now having implications for conservation. And of late we have been becoming more and more aware of these conservation implications, as shown by these articles. We show that free trade increases world pollution. So, the more the amount of free trade the more is the world pollution.

There are a number of externalities that are involved. China's international trade and air pollution in the United States. Then we have international trade that undermines national emission reduction targets. So, every country these days has certain national emission control targets, which means that every country is trying to cap the amount of greenhouse gases that it is emitting.

But then international trade is undermining that effort because there are certain countries that are producing greenhouse gases to such a large extent that now these national targets are not being fulfilled.

What is happening is that, suppose a country in Europe states that we are going to reduce our carbon dioxide emissions by 20 percent by the year 2020. So, what they are saying is that, we will emit only 80 percent of the carbon dioxide that we were emitting in the year 1990, but then this is not being completely met because they are still getting more of the produce, but they are getting it from certain other countries, such as China.

What happens in that case, is that the country in Europe would be able to show that, yes we have reduced our greenhouse gas emissions, but then that is that has been more than compensated by the excessive release of carbon dioxide in China. And in this case not only will carbon dioxide emissions be there during the process of manufacturing of the goods, but there will also be a large amount of carbon dioxide emission during the transportation of the goods.

When the things were being made locally, in that case the amount of carbon dioxide emissions were less, because things had to be transported to lesser distances, but now things are moving across continents and that is also leading to an increase in the total amount of, the net amount of greenhouse gas emissions across the world. So, this is another major environmental implication of international trade.

International trade linked with disease burden from airborne particulate pollution. Now, this article is stating that the pollution that is being released because of international trade is now leading to more and more diseases in a large number of people. Especially airborne diseases, because if there are pollutants that are released in any one country, then along with wind these pollutants can reach the other countries and they will start to have negative consequences on the people in

the other countries as well.

We are starting to see an increase in the disease burden. Pollution from international trade killed 700000 people in one year, 700000 premature deaths worldwide in a single year. So, it is not just a theoretical construct, but what we are seeing is that this is actually happening.

International trade and air pollution; estimating the economic cost of air emissions from water-borne commerce vessels in the United States. Now, what is happening is that because of the air pollutants that are being emitted by certain countries that are involved in international trade, we are now seeing a large amount of disease burdens across the world, which means in other countries as well. Now, because there is a disease burden, these countries will have to spend more resources on health care. So, there is an economic fallout of international trade as well.

In total, what we are seeing is that international trade is having a large amount of environmental and disease related implications. But then the question is, if international trade is bad for us then why are we doing it? So, we cannot just say that international trade is good or international trade is bad, but when we know that international trade has an implication for the environment, has an implication for conservation, we need to understand international trade, so as to be able to better regulate it.

We need to know not just the negatives, but also the positives of international trade. So, we can find out a way in which the positives can be retained by reducing the negatives. Which is why this lecture is important. We need to know, not just that international trade is leading to an increase in confusion, but we need to understand what are the benefits of international trade because of which international trade is occurring, and is there a way in which we can have these benefits without the large amount of air pollution or other pollution.

The question is, why international trade? Well, international trade has several benefits. It increases the variety of goods that are being made available; this includes not just consumer goods, such as food or clothes, but also includes things such as technology or medicines. So, a country that is not making a particular medicine, but the people who need that medicine can import this medicine from a country that manufactures the medicine.

So, international trade increases the variety of goods that are made available to any particular country. Secondly, specialization permits economies of scale, which lowers prices.

What this means is that, if a country specializes in making something, say a country is specializing in making clothes, when that happens the country would get into the profession of making newer technologies available, it would put money into research on how to make clothes in a better manner or more cheaply, it would try to have a vertical integration of the different components of making clothes, and when all of these happen then it is doing a specialization into this activity of taking clothes. The net result would be that clothes of better quality will be made at cheaper prices.

So, specialization which is resulting because of international trade. Now, international trade in this case is important, because if international trade was not there then the domestic market would perhaps be a very small market and in that case it would not make much economic sense for the country to put in a large amount of money into research or into new technologies for making the clothes.

Because the domestic market is so small that the country would not be able to recuperate the cost. But with international trade the market would be so large that it would become economically incentivizing, economically feasible, for the country to put money and resources into specialization, and when that happens we will start getting closer at lower prices and with better quality. And that would benefit not just the people in that particular country, but also people all around the world.

So, international trade is important because it permits a specialization which further permits economies of scale and lowers the prices. Then increased competition reduces the market power of firms and consumers. What that is saying is we had looked at market power. Market power is the phenomenon, when a few producers or a few consumers are in a position to alter the market prices, and a very good example is the organization of petroleum exporting countries or the OPEC.

Now, if OPEC decides that they are going to raise the prices of petroleum and if the international trade was not there, if OPEC was the only consortium that was able to provide petroleum, in that case they would be having a very huge amount of market power. But, if international trade permits a number of other countries who are not members of OPEC to also extract petroleum and to sell petroleum, then that is the market power of OPEC will be much lowered. Because what will happen is that, if OPEC increases the prices then the other country could sell larger quantities of petroleum because they are selling it at a lower cost.

All the countries would want to purchase petroleum at lower cost, so essentially, the country that is not a member of OPEC would be able to supply a larger portion of the international market. And, they would be able to do that by lowering the prices, that is not increasing the prices to the level where OPEC is planning to sell. And, the benefits would be reaped not only by that country that is not a member of the OPEC, but the benefits will be reaped by the whole world, because everybody would be getting petroleum at cheaper prices.

A benefit of international trade is that it increases competition and reduces the market power of firms and consumers. Similarly, if the number of consumers were less, in that case the consumers would be having market power. That is, if the consumer would say that we are not going to purchase above this price, then the producers would be at a loss. But with international trade what happens is that there are so many consumers, that if there is one consumer that is ready to buy things at a larger price then people will supply the goods to that particular consumer.

So, essentially, with a larger number of producers and larger number of consumers the market power of everybody reduces. Now, when market power reduces, it means that the market will be able to function in a much better manner in a much more natural manner, that is the market will become more and more competitive. And as we have observed before, a competitive market enhances the net surplus.

It optimizes for the maximum amount of surplus for the whole of the society. So, it is always good to have more producers and consumers so that the market power is reduced, because market power is an aberration that does not permit the market to work properly. So, this is another benefit of international trade.

Then there are enhanced flow of ideas, such as a computer revolution can begin by importing a

few computers from abroad rather than making them domestically. What we are saying here is that with international trade it is possible for countries to leapfrog.

Leapfrogging; leapfrogging means that a country can move from a state of technology, say, state 1 to state C by overcoming state B. What we are saying here is that, in a normal course of action say a country would have begun with stage A, which is say telegraph, and from telegraph the countries move to a stage B which is say landline phones, and from stage B they move to stage C which is mobile phones.

Now, generally, if international trade was not there every country would move from a telegraph, to a landline, to a mobile because the level of technological progress in any country would be very less. But with deep frogging what happens is that the country who is in stage A can import the mobile phones from another country that is making those and it can directly move from stage A to stage C.

So, international trade by making available those items that you do not have to manufacture in your own country permits a country to leapfrog. So, to move from a primitive stage to a very advanced stage by removing the rungs of the ladder that were constraining the countries to move in the middle stage.

Similarly, if a country wants to move from a primitive economy into say a tertiary economy by having more of the service industry. So, the country might say that ok let us move into say the software industry.

Now, earlier if the international trade were not there then the country would have to first manufacture its own computers, which would mean that from a primary industry it would shift to a secondary industry of manufacturing and only when it would have a sufficient number of computers would it move to into a tertiary economy which is the making of the services such as software.

But with international trade it is possible that a country that is in our primary economy, that is it is more dependent on natural resources than on industries, it can directly import these machines the computers and say telecommunication equipment and it can directly move from a primary economy into a tertiary economy, that is the service industry, software industry.

International trade makes it possible for countries to move to a very advanced level of economy or to a very advanced level of development by permitting enhanced flow of ideas and technology. And with all of these, it leads to an enhanced surplus and welfare for the people, which is ultimately what we want. So, even when we are doing conservation, we are doing it for the people, because conservation provides benefits to people.

Similarly, international trade provides certain benefits to people, which is why we are doing international trade. Now, the point is how do we make a balance? How do we ensure that we are having an interaction trade in such a manner that we are also able to perform conservation? To understand that we now need to understand how international trade is able to enhance the surplus of people, how it is able to enhance the welfare of people.

To understand that we would have to get into the concept of world price. World price is defined as the price of a good that prevails in the world market for that good. It is the price of a good that prevails in the world market for that good. Essentially what we are saying is that when we are

talking about international trade, there is a domestic price for things and there is an international price for things.

If we look at a thing such as a pen, now a pen when it is manufactured domestically when we have it sold in the market for a certain price and when the same pen is made available to the world market then it would perhaps be sold at a different price. So, what we are asking in the case of international trade is what is the world price.

Essentially what we are saying here is that we have observed that in the case of a market, we have the supply curve and the demand curve and here we have the price and here we have the quantity.

We have a supply curve, we have a demand curve and where both of these meet will give you the quantity and the price. But this is the demand and supply curve in the domestic market. But what happens is that, when we start to look at the international market, probably there are certain sellers who are able to supply things at a lower cost or probably there are certain consumers who want to purchase these items at a much higher price, because they have a much larger value to these products.

Essentially, what we have observed is that the demand curve tells the value that people are putting, the value to consumers and the supply curve is an indication of the cost to the producer. Now, it is possible that in the international market the value to the consumer may be different and the cost to the producer may be different because we are talking now about a very large number of producers and consumers.

So, a thing that can be made at a higher price in our country, it is possible that it may be made at a much cheaper price in some other countries, or also the reverse. Some things that we are able to make at a cheaper price it is possible that the other countries are not able to make those things at that cheaper price.

Which would bring a difference in the domestic prices and the international prices and also the domestic quantities demanded, and supplied and the international quantities that are demanded and supplied.

Essentially what we are saying here is that, together with the domestic demand and supply we also have an international demand and supply. Let us say that this is the demand and supply internationally. So, now, we are talking about the international market. That is when all the countries are doing the trade. Now, in this case, we will be having a different price, let us say that this is P' and a different quantity than in the domestic market, let us say that this is Q' .

Now, P' may be the same as P or it may be different from P , but this P' will be called the world price. The price of a good that prevails in the world market for that good. It may be the same or different from the domestic price. The world price may be the same as the domestic price or it may be different from the domestic price, but world price becomes very important in the case of international trade. Why?

Because these prices are an indication of the cost of manufacturing to the producers. And in this case, if the domestic price is less than the world price, what does that mean? It means that our manufacturers or our producers are able to make things at a much cheaper cost than producers in other countries. Which means that we are making things much more efficiently.

If we are able to make things at a cheaper price and others are able to make things at a much greater price then that would mean that we have an advantage over the other countries. Now, in the case of trade we have observed that people or countries should be doing what is what they are. They have an advantage in doing, whether it is an absolute advantage or a comparative advantage. Because, when we have the advantage then we are able to make things at a cheaper price, which means that we are in a much better position to sell and to earn money.

It will be of benefit to our country, but then it will also be offer benefit to the other countries because their domestic industries are not able to make things that cheaply, but they will be able to import these things from our country and so their citizens will also be able to get these things at a much lower cost than what their industries were providing.

If there is a difference between the domestic price and the international price, and if the international price is higher, then it makes sense for us to export because we are at an advantage and we will be earning the foreign exchange. At the same time, the other countries - it is in their advantage to import because they will be getting things at a cheaper price.

Similarly, if the world price is less than the domestic price, it means that for that particular good our industries are not that efficient. They are not able to make things at that lower cost than is available in the world market. In that case, if we imported those goods then we would be able to provide those goods at a much cheaper price to our citizens. We will be able to increase the benefit or the surplus of our citizens. In that case, international trade makes sense.

Let us now explore both of these situations. What are the gains for an exporting country and what are the gains for an importing country? So, when we are saying an exporting country then it means that the domestic price in this case is less than the world price.

So, let us now start from the domestic surplus. Now, in the domestic market these are the demand and supply curves. And the point where both of these curves meet, it gives us the prevailing domestic price and the domestic quantity demanded or supplied. And we have observed before that this triangle which is between the demand curve and the price gives us the consumer surplus and this triangle which is between the supply curve and the price, it gives us the producer surplus.

This is the situation before international trade. We have the consumer surplus, we have producer surplus, and this total is giving us the total surplus of the country before international trade.

And this country is going to export if the international price is greater than the domestic price, which is what we are showing here. So, this line is showing us the international price. This is the international price and this line is the domestic price. So, this is the price before the international trade, given by the meeting of the supply and the demand curves and this is the international price which is also the price that will be there in the domestic market once you have the international trade.

Now, why is that so? Suppose you have a producer who can sell things at a higher price in the international market, because the international trade will occur when you open the economy. When you permit the manufacturers in your country to sell things abroad. Now, it is a prerogative of the government to stop it. The government might say that no there will not be any international trade; we will not permit the manufacturers to sell things outside.

If that happens, we will have this situation. So, there is no international trade. Now, if the government says that no, you can sell things to people outside, in that case we have observed that the producer surplus is the difference between the price at which the item is stored and the cost of making that item.

So, the manufacturer, to increase their producer surplus, what will they do? Is that they would want to sell things to those people who are going to pay them a higher price, larger price. Now, if I can sell this pen in my country for 10 rupees and if I can sell this same pen in the international market for 15 rupees, and I am a manufacturer, then in that case I will prefer to sell it for 15 rupees, because in that case my profit will be more.

If the people in the domestic market want to purchase these goods, they will also have to pay 15 rupees, otherwise I will not sell it to them, I will sell it at the international market. Which is why the international price becomes important because once you open the economy then the international price will be the price that you will have even domestically.

Now, the amount of supply earlier was given by this line. This is telling us the quantity that is demanded or supplied. This is the quantity demanded or supplied. Now, in the case of international trade, what will happen is that the domestic supply will be given by this point. This is the point where the demand curve is intersecting with the price curve.

Now, we have observed that once the market has been opened, the international price is the price that will prevail in the domestic market. Now the thing is how much is the quantity demanded or supplied at this price point? The quantity that is demanded at this price point will be given by the point where the price line cuts the demand line.

This is the point. And at this point the quantity that is demanded in the domestic market is given by this line. This is the domestic demand or supply, because the quantity that is demanded will also get supplied.

The total quantity that is supplied or by the producers is given by this point, where the supply curve this one intersects with the price curve. This point will tell us the total supply. Now, this is the total amount that is being supplied by the producers and this is the total amount that they are supplying to the domestic market. So, we have two things. We have a total supply and we have a domestic supply.

Essentially, if we say that domestically a seller is selling say 300 pens, but in total the seller is selling one thousand pens, so the difference between both of these is 700 pens, in this case we will say that they are getting exported out. Because the seller is supplying these pens but not to the domestic market. So, if the seller is not supplying it to the domestic market, who is he or she supplying it to? The answer is the international market.

The difference gives us the total amount that is being supplied outside or the total amount that is getting exported out. The difference between the total supply and the domestic supply gives us the amount of export.

Now, let us have a look at the surplus. Now, before international trade we were having the consumer surplus that is given by the yellow triangle, and let us say that it comprises this portion A and this portion B. So, what we are saying here is that, this much portion is A and this much portion is B.

So, we are dividing the consumer surplus into these two parts A and B, and the producer surplus is given by this green triangle. This is the total producer surplus C. So, before the trade this was the situation.

Now, after the trade what is happening is that, now this is the prevailing price point. So, now, the total consumer surplus is given by the area between the demand curve and the price curve.

Now, this is the total consumer surplus. Because here we have the demand curve, this is the price line and so this area, this yellow coloured area that was that we had written as before, this is the new consumer surplus. Similarly, the producer surplus is the area between the supply curve and the price line, so the new producer surplus will be given by this larger triangle.

In this case, we can extend the supply curve till this point where it touches the price point and, so this big triangle is now the new producer surplus. Producer surplus now is B, this portion plus C, this triangle plus D, this is the new producer surplus.

If we look at the total surplus, before trade we were having a consumer surplus that was A plus B which is what we are writing here, so before trade consumer surplus was A plus B, before trade the producer surplus was C which is what we are writing here. So, the total surplus before trade was A plus B plus C.

After trade what is happening is that the new consumer surplus is A, which is what we are writing here. The new producer surplus is now B plus C plus D which is what we are writing here, and so the total surplus is A plus B plus C plus D which is what we are writing here.

If we look at the consumer surplus, before trade it was A plus B, after trade it is only A. There is a net change of minus B, which means that the consumer surplus reduces. So, the result of the international trade is a reduction in the consumer surplus, and this reduction is happening because the domestic price levels have gone up.

As we had seen before, the consumer surplus is the difference between the value that the consumer puts on the good and the price at which they are able to get it. If price increases then surplus reduces and that is what we are observing here, because this is an exporting country which means that the domestic prices were lower and the international prices were higher.

After the trade the domestic prices also increase, they become equal to the international prices and with the increase in the price there is a reduction in the consumer surplus.

The producer surplus earlier was C; the new one is B plus C plus D. So, there is a net change of plus B plus D which means that the producer surplus is increasing. Now, the producer surplus as we have seen before is the difference between the price that the producer will get and their cost of manufacturing of the cost of producing that particular good. Now, the cost of manufacturing will not change because of international trade, but the price that the producers get will actually increase.

Now, with the increase in price, then total profits will increase which means that their surplus will increase. And the increase in the surplus is given by plus B plus D, so there is an increase. So, the consumer surplus reduces the producer surplus increases.

What about the total surplus? Earlier it was A plus B plus C, but now it has become A plus B plus C plus D, and so the change is plus B, so the total surplus increases.

Now, we had said before that the aim of the policy should be to increase the total surplus, be-

cause we cannot be favouring the producers or the consumers, and so, if we want to look at the welfare of the society we should keep a target of increasing the total surplus. And here, we are observing that for the exporting country the total surplus increases if they get into international trade.

The total surplus before the international trade was less, after the international trade it is more. So, it makes sense for the exporting country to get into international trade. So, international trade is beneficial for the exporting country. But what happens to the importing country?

As before, this is the domestic surplus before the import. We have the consumer surplus in yellow, we have the producer surplus in green. Now, because this is an importing country, now a country would import when the international prices are less than the domestic prices, which means that the country is able to get the things cheaply from abroad and it takes much more money to make it domestically in the country, only then a country would import.

In this case, the international prices are less than the domestic prices. And we are representing that here. If we look at the domestic demand and supply, the point where these two curves meet tells us the domestic price before the international trade. In this case, the domestic price is low and the international price is less which is why this country is going for the import. Here we are representing the international price or the world price by this red line.

Before the international trade, this would be the price, after the international trade begins we will have this price. And remember, that this is the price that we will get even in the domestic market. Why? Because once the country is opening up for imports, now, the consumers have an option whether to buy the domestic product or whether to buy the international product.

If quality remains the same, the consumers would want to purchase things at the lower price. So, they would go for the item that has been manufactured internationally because it is available at a cheaper price. And so, the domestic producers would have the option of either reducing the price to match the international price or going out of business. So, which is what we are observing here. So, we have this as the price after international trade even in the domestic market.

Now, the total quantity that is demanded in the market is given by the point where the demand curve intersects the price curve. This is the demand curve and it is cutting the price curve at this point. This is the total supply that is being demanded or this is the quantity that is being demanded and supplied in the domestic market.

For the domestic producers, the supply curve was this, and the point where the supply curve is cutting the international price is telling us the domestic supply. So, this is the quantity that the domestic producers are able to supply and this is the total quantity that is being supplied in the market.

What we are saying here is that, the total supply is 1000 pens as we have seen before; the domestic supply is 300 pens. Now, that is the difference in both of these cases, so total supply in the domestic market is 1000 pens out of which only 300 are being supplied by the domestic producers, so the rest of these 700 pens will be in this case imported.

This difference between Q and Q_D is telling us the amount of import in this particular.

Let us have a look at the change in the surplus. Before international trade we were having a consumer surplus and a producer surplus. Now, because we have this red international price line, we

divide the producer surplus into B and C and this is the consumer surplus. So, the consumer surplus before trade was A and the producer surplus was B plus C.

Now, what happens to the surplus after international trade? Now, the producer surplus is given by the area between the supply curve and the price curve. So, this triangle is telling us producer surplus after international trade, because now the price point is this red line. The producer surplus in place of B plus C has now reduced to only C, and the consumer surplus is given by the area between the demand curve and the price.

Now we can extend it till this international price and this triangle is now telling us the consumer surplus. The consumer surplus now is A plus B plus D. If we make a table, before the trade we were having a consumer surplus of A which is what we have written here, and a producer surplus of B plus C which is what we have written here. Before the trade we were having A and B plus C.

After the imports are permitted, the consumer surplus now is A plus B plus D which is what we have written here A plus B plus D and the producer surplus is C, which is what we have written here C.

Now, in this case you can observe that before trade consumer surplus was less after the trade the consumer surplus has increased and the change is plus B plus D, which means that for the importing country the consumer surplus increases, which is because the consumers are now able to get the products at a reduced price and the consumer surplus tells us the difference between the value that the consumers put on the good and the price at which they are able to get it.

Because of the trade, the value will not change but the price has reduced and so the consumer surplus has increased. In the case of the producer surplus before it was B plus C, now it is only C. There is a net change - it is minus B. So, the producer surplus has gone down. And why has it gone down?

Again because, the producer surplus is the difference between the price that the producers get and their cost of making the things.

The cost of making the goods does not change, but the price that the producers will get it has gone down which would reduce the producer surplus. And the quantity is minus B. But when we are making the policy, we are more interested in the total surplus. Now, earlier the total surplus was A plus B plus C which is what we have written here, after the trade it has become A plus B plus C plus D. And so, there is a net change of plus D in the total surplus, so the total surplus increases. When the total surplus increases it means that the welfare of the society increases.

So, the welfare of the people who live in the country that is now importing the goods, has increased because the country has decided to import the goods. The total surplus increases not only for the exporting country but also for the importing country, and which is why international trade actually happens, because it increases the total surplus. But then we have the role of the government.

The government may say that let us give certain amount of protection to our manufacturers, because the producer surplus goes down whenever there is an import. So, the government may say that no, we are not only interested in the total surplus, we are also interested in the welfare of our manufacturers. We need to protect our manufacturers. And how does the government protect the

manufacturers in the case of input? By putting in an excess charge on the imported goods. This protection is done by, this was the earlier situation, but now the government says that we will add a tariff. Which means that any goods that are imported will not be imported at this price, but we will put a tariff which is now shown by this blue line.

This difference is the tariff and so any import will have to be made at this price. So any quantity of goods that is being imported, it will have an extra charge, which is the charge of tariff and this is the money that the government will keep to itself.

The government says that we are going to we are putting this tariff to produce our to protect our producers, and so if you import this pen from any other country and if this pen is available for 10 rupees we will put a tariff of 2 rupees, which means that if anybody wants to purchase this pen from outside this pen from the international market they will have to pay 12 rupees. And out of these 12 rupees the 10 rupees goes to the other country that has supplied this good and 2 rupees are now with the government.

Now, the benefit of the tariff is that, the disadvantage to the domestic producers is reduced. Because, earlier the domestic producers were manufacturing this pen for say 13 rupees and it is available in the international market for 10 rupees. So, everybody wanted to have this pen. But now with the tariff this international pen is available at 12 rupees and the domestic pen is available at 13 rupees. So, the amount of comparative disadvantage that the domestic producers were having has now been reduced from 3 rupees to just 1 rupee. So, it is now possible that they will be able to sell more pens.

This is the price after international trade and with the tariff. This is the price before international trade or the domestic price. With international trade the price came down, but with the tariff it increased again, but it is now between the domestic price and the international price.

In such a situation what happens? Earlier, we were observing that this much was the domestic supply. So, the domestic supply was given by the point of intersection of the domestic supply curve with the international price or the world price. Now, the price has increased because of the tariff. And so now, the domestic supply after the tariff is given by this point where the domestic supply curve is now intersecting the new price curve. And at this price point, now this much is the quantity that is supplied domestically.

What we are observing here is that, earlier the domestic suppliers were only supplying this amount, but now they are supplying this amount. The total amount that is being supplied by the domestic producers has gone up. Which was one of the aims of putting up a tariff to provide protection to our domestic manufacturers. So that they do not completely go out of business. That they also have certain amounts of goods that they can sell and now it is more than what they could have sold if there was just a free input of goods.

Now, earlier the total supply was this much, given by the domestic demand curve cutting the international price or the world price. Now, because the price has increased, so now, this is the point which will tell the total supply. This is the total supply after the tariff, the point where the demand curve is setting the new price curve. This is now the total supply. So, there is a decrease in the total supply, so earlier total supply was this much, now it is this much. And the difference between the domestic supply and the total supply will give us the amount of import.

Earlier the import was this much. The red arrow line and the new import is this much. What is happening is that the country has now reduced the total amount of imports. Now, a reduction in the total amount of imports would also mean that the domestic suppliers or the domestic producers, are able to supply more, but at the same time we are now using less amount of foreign exchange to pay for goods that are manufactured outside.

We are even saving on our foreign exchange. So, this is what is the situation after the tariff. Now, let us analyse if it increases or decreases the total surplus. Now, before the tariff we had a situation like this. So, the consumer surplus was A plus B plus D the producer surplus was C, which is what we have seen before. Now, with the tariff to analyse it, let us divide this portion B into B1 and B2 and this triangle D into D1 D2 D3 and D4.

We are not making any changes, but we are just saying that in case of writing D we will say that the consumer surplus is now D1 plus D2 plus D3 plus D4 and in place of writing B we are now writing it as B1 and B2. The consumer surplus remains the same. It is A plus B1 plus B2 plus D1 plus D2 plus D3 plus D4 and the producer surplus is C. So, this is the situation before the tariff. What happens after the tariff is imposed? Now, the consumer surplus will be given by the triangle that is formed by the demand curve and the price curve. This is the new consumer surplus. The new consumer surplus is A plus B1 plus D1, which is what we are writing here, A plus B1 plus D1.

The new producer surplus is given by the domestic supply curve and the price curve. This is the new producer surplus, which is C plus B2 which is what we are writing here. And the amount of revenue that accrues to the government is given by this rectangle which is D3. Why? Because, this is the amount of input and this is the amount of tariff.

The government revenue is imports into the tariff. So, more the amount that is getting imported or more is the amount of tariff the government will earn more revenue. So, for each pen the government was charging 2 rupees of tariff. Now, if 10 pens are imported the government gets 20 rupees, if 100 pens get imported the government gets 200 rupees.

Similarly, it has got to do with the amount of tariff, if 10 pens were imported and the tariff was 2 rupees then the government gets 20 rupees, if the tariff increases to 3 rupees then the government gets 10 into 3 is 30 rupees. So, we are representing that by this rectangle D3. So this is the surplus after the tariff.

If you put it in the form of a table, before the tariff that is when you talk about this situation, the consumer surplus was A B1 B2 D1 D2 D3 D4, A B1 B2 D1 D2 D3 and D4 that was the old consumer surplus.

The old producer surplus was C which is what we have written here and the amount of government revenue was nil. After the tariff we have the consumer surplus as A plus B1 plus D1 here, the producer surplus is C plus B2 which is here, and a government revenue of D3 which is what we are writing here. What is the change? The consumer surplus it has reduced. This is the amount of reduction and the consumer surplus has reduced. Why? Because the tariff has increased the prices, and more the prices means less the consumer surplus.

The producer surplus has increased. Why? Because the tariff has increased the prices. More the prices, more is the producer surplus. The government's revenue has also increased, earlier it was

0 it is of some amount, but then what happens to the total surplus? The total surplus in this case has gone down. Which means that even though putting up the tariff is going to benefit the producers and the government, it is not going to benefit the society in total because the total surplus goes down with the tariff, and which is one of the reasons why tariffs are not that good for any society.

We can sum up by remembering that trade can make everyone better off. And this is why we are observing trade in today's world international trade because it is increasing the surplus for the exporting country, for the importing country, and any position of tariff may lead to a decrease in the total surplus.

That is all for today. Thank you for your attention. Jai Hind!

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Module 8
Public sector and Conservation
Lecture 1
Externalities

Namaste! Today, we begin a new module which is Public Sector and Conservation. This module will have 3 lectures - Externalities, public goods and common resources, and the design of the tax system. This lecture is about externalities. But before we begin, let us have a look at this principle of economics that we are touching in this lecture. Markets are usually a good way to organize economic activity.

Why are markets good ways to organize economic activity? Well, there are several reasons. Things like, there is an option of a free will, the buyers and the sellers see for themselves what is in their best interest, and they act according to their own best interest.

There is an option of free will; there is an option of choice because the market is going to provide those goods and services or those variety of goods and services that are going to increase the welfare of the buyers and the sellers.

At the same time there is a quick transfer of information, there are prices that act in the market that provide information about the demand and supply in the market. So, if the price of something is high, it means that that particular good probably is in high demand, and that would give a signal to the sellers to manufacture more and more of that good, so that they can also have a share of the profits.

And at the same time all of these also increase the efficiency of the system. So, it increases the benefits of the majority of people in the society which is why we say that markets are a good way to organize economic activity. But the thing is they are not always. It says here markets are usually a good way, but not always. Why?

Because when the markets are working by themselves, we have observed or we have suffered from a number of environmental and ecological damages things such as the Minamata disaster of Japan. Now, we will look at this in greater detail in the 12th module, but in short the Minamata disaster occurred because there was a company producing acetaldehyde that was dumping the used catalyst into the oceans.

So, whenever there is a production process, there will be some kinds of waste that are generated. Now, in this case in the case of the Chisso factory that was manufacturing acetaldehyde the waste was they spent catalyst that was having mercury inside. Now, the company could have done two things. One, it could have treated the waste before it was disposed of which was the

right option, but it would have incorporated a certain cost to the company.

The cost of trading the cost of installing equipment in the company to treat the waste. That was the right approach, or the approach that we as a society would have preferred. But for the company it was something that was in it that would have led to an increase in the price or an increase in the cost of production.

What they did was, they did not treat any of the suspended catalyst and it was directly dumped into the seas. Now, when you add mercury into a system, mercury is a heavy metal and causes a number of neurological disorders. The nerves of the body do not function that well when somebody is fed with mercury.

In this case what happened was when the suspended mercury or the compounds of mercury when they were dumped into the seas, it started entering into the bodies of several organisms. And in a short while people started to observe that the fish in the seas were dying and they were coming on top. They were floating on top and Minamata happened to be a very good fishing village, fishing was the major occupation in this village.

And in a fishing village when you observe that so many fishes are dying off, it creates a problem of livelihood because if there are no fishes what will the fishermen do. Second thing that they started to observe was that the cats in the city started to show very bizarre symptoms. They started to show repeated movements, they started to commit suicides because of the neurological disorders.

After a few more years, people started to document that we were seeing all these symptoms in humans as well because the humans who were eating the fish from this sea that was contaminated with mercury were also getting mercury in their own bodies by means of this food - the fish. And so people also started showing a number of neurological disorders.

When the cost was computed of the extent of environmental damage, the extent of health damage, and the extent of social damage, it ran into a compensation of billions of years of billions of yen per year. So, that is the Minamata disaster of the 1950s. Now, in this case, the company could have treated the waste before it was being dumped.

In that way, this disaster could have been prevented. But then because the company was acting only in self-interest, it was not looking at the interest of the society, so it ended up committing such a big blunder that it ended up paying a huge amount of money out of the company's coffers as well. Now, this could have been prevented had this externality been internalized in some manner.

Another example is the London smog of 1952 in which so much pollutants were released that it created a big social menace. The release of dioxins from the Seveso plant in Italy in 1976. The Love Canal waste dump, now this is a very important waste dump story because in this case what was done was that these waste the industrial waste extremely toxic chemicals, they were just dumped into an area with no treatment at all.

After a while this dump yard was covered with a small bit of soil, and then it was sold off to be constructed into a school. So, a school was actually constructed on top of a dump yard that was having extremely toxic industrial chemicals.

When the pupils in the school started showing symptoms when the pupils started getting ill, then

people came to know about this. Now, in this case as well there was a company that was dumping these waste to cut its costs, it is just a cost cutting approach nothing else.

If we have a look at the Bhopal gas tragedy in our country in 1984, in this case as well it was just a simple matter of cost cutting. What the company did in those days, the Union Carbide Corporation, what it did was that to cut costs it started accumulating the MIC liquid that was extremely toxic and should not have been accumulated in large quantities.

And then when it was accumulated, it was kept in those tanks that were not that well maintained. So, into those tanks water was able to seep in. The liquid had to be kept refrigerated because it was extremely reactive when the temperatures went up, but the refrigeration unit was shut down to cut costs.

Also when the gas got released because of this poor maintenance, the flare towers were not working, the chemical wash towers were not working. So, all of these things could have been prevented had the company actually spent some amount of money into proper maintenance.

Now, that was expected of them because as a society we do not want to have companies that release such toxic chemicals into the environment.

But a company that was only working on a profit motive, it did not consider these social costs that get involved. Again here is when there was an externality in pain. Or the Chernobyl nuclear accident or deforestation pollution global warming you name an environmental problem, and there are a number of externalities that are involved in most of them.

So, while markets are usually a good way to organize economic activity, they are not always because of a number of market failures. Now, what is the market failure? The markets have a big role to play in our society because they increase the welfare of the people, they increase the welfare of the buyers, they increase the welfare of the sellers. And theoretically they should bring the society to a level that is the optimum level.

So, you cannot increase the welfare of any particular person without reducing the welfare of someone else. hm In those situations, they say that it is an optimal level of welfare.

Markets, if they work well, should be able to bring the welfare to the optimum level because each seller will be able to get the highest profit for what he is making, and each buyer will be able to get all the products at the cheapest possible cost and at the best quality. Now, this is what the market is telling us. But a market failure occurs when through some processes this optimality or this level of welfare is not reached.

So, market failure is a situation in which a market left on its own fails to allocate resources efficiently, that is it fails to allocate the resources things like money, things like time, things like resources to those units or those companies that are acting in the best welfare of the society, so that is a market failure.

And two major causes of market failure are externality and market power. Externality is the impact of one person's actions on the well-being of a bystander. So, in the case of externality, what we are saying is that there is an actor who is doing something, and because he is doing that there is an impact on a bystander who has got nothing to do with that action.

For instance, the students who were studying in the school that was built on the Love Canal site, they had got nothing to do with the dumping of these toxic industrial waste into the Love Canal,

but still they had to suffer the consequences. So, that is an externality because the action was done by one company to put untreated toxic industrial waste into a Canal site, and to sell that off to for the construction of a school.

But the impacts were suffered by the students - small children who had got nothing to do with that. So, the small children in this case, the pupils were the bystanders. And the company who was dumping these chemicals was the actor in the case of Minamata disease as well.

The company Chisso Corporation was the actor who did the action of dumping untreated mercury laden industrial waste in the form of spent catalyst into the seas. The fishermen did not ask the company to dump that.

The fishermen were completely bystanders, the fishes were completely bystanders, the cats in the city were bystanders, the residents of the city or of nearby places were all bystanders. They did not ask the company to do that.

But the company made this mistake of dumping the chemicals, but the consequences were suffered by all of these. Or the Bhopal gas tragedy, in that case the people of Bhopal did not ask the Union Carbide Corporation to maintain its plants in a sub optimal level to store a large quantity of the MIC gas and to shut down all the safety precautions, the people of Bhopal did not do that. They had got nothing to do with the action of the company which was to cut down the cost. And to blatantly flaunt all the good practices that are required in the storage of this chemical MIC. But then this suffered when this chemical got released. So, the people of Bhopal in this case were the bystanders.

All of these are examples of externalities and the impact of one person's actions on the well-being of a bystander. Another cause of market failure is market power. The ability of a single economic actor or a small group of actors to have a substantial influence on market prices. A good example is a person in a village that is suffering from drought conditions and this is the only person with a well.

So, you can charge any amount of money. Or another example is say a contractor that is purchasing sugarcane from a very large area, and he is the single contractor. Now, in that case whatever price he offers is the price that the farmers of sugarcane will get. So, he has a tremendous amount of market power.

We can have market power in terms of the seller, for example, the owner of the well in the drought village or in the form of the buyer when you have only a single buyer such as the contractor of sugarcane from a very large number of villages.

If you have buyers or sellers who are in a very small number, in those circumstances it is very much possible that one or a few buyers or sellers may influence the market prices, and that is known as market power. So, they are having power over the market in terms of the price that the market brings up.

Now, in this lecture, we will focus on externality, the uncompensated impact or the impact of one person's actions on the well-being of a bystander. And when we talk about externalities, we can have negative externalities or positive externalities.

Negative externality is when the bystander is impacted in a negative manner such as if there is a company that is releasing pollutants, the people in the surrounding area have to suffer the health

consequences and so it is a negative externality.

And so in certain other cases we have a positive externality such as things like vaccination. So, if people get vaccinated, they are not only protecting themselves, but they are also providing herd immunity for the community which means that the diseases will not be able to spread that easily in a community where a large number of people are already vaccinated.

So, they are providing a positive impact through their vaccination, through their action of vaccination, they are providing a positive impact to the bystanders in the community who did not ask these people to get vaccinated, who did not pay money for them to get vaccinated, but they also receive a benefit because their community and from that they themselves are now less prone to getting the disease. That is the positive externality.

We can also talk about production externality and consumption externality. The production externality is something that occurs when there is a production of a good. Consumption externality is something that occurs when there is a consumption of a good. When the company is producing something and is releasing pollutants this is a production externality.

If somebody is buying those products, then through this process of buying or through the process of using certain products if they are releasing pollutants, then it is known as a consumption externality. A very good example is those vehicles that release a large amount of smoke.

The people who are consuming these vehicles, who are using these vehicles, are spreading pollution into their communities by means of consuming this pollution spreading vehicle.

In this case, they will say that it is a consumption externality. So, let us now look at these four combinations. So, we have negative or positive, and we have production and consumption.

So, we can have negative with production, negative production externality. Negative consumption externality, positive production externality, and positive consumption externality. And we look at all four of these.

Let us begin with the negative production externality. There is a production that is going on and it is leading to a negative externality or negative consequences. When a firm's production reduces the well-being of others who are not compensated by the firm. When a firm's production, there is a production that is going on and this production reduces the well-being, which is negative of others who are not compensated by the firm.

Good examples are industrial pollution and loss of ecosystem services due to mining. Now, in the case of mining, there is a company that is doing a production of these minerals or coarse. And because of this activity there is a loss of ecosystem services in the form of say clean air or clean water in this area. So, this is a negative production externality.

Industrial pollution also is another negative production externality because the industry by means of producing something the producing goods it is creating pollution in the surroundings that is reducing the well-being of others who are not compensated by this particular industry.

In the case of negative production externality, we can differentiate between the private marginal cost and the social marginal cost. What is that? Private marginal cost is the direct cost to the producers of producing an additional unit of a good. It means that suppose there is an industry that is manufacturing pens. And in the manufacture of pens, they are using a process that releases a large amount of smoke to take a hypothetical example.

The cost that it takes the company directly to manufacture one additional unit of a pen is the private marginal cost. So, it is a private cost. So, this is a cost that is being paid by the company. So, it is a direct cost to the producers. And at the same time, this is a marginal cost which means that it is the cost of producing an additional unit of a good, just one more pen. How much does it cost the industry to manufacture just one more piece of pen?

Now, this is marginal, because we are not talking about an average cost, we are not talking about the cost of manufacturing a hundred pens, we are just asking the question what is the cost of one more unit of production. And direct cost because it is the cost that will be paid by the company. Another cost that is involved is the social marginal cost. When society uses this good, now when the producer is making it, it is the producer who is making it for somebody. So, somebody is going to purchase this good.

Now, the buyers who are going to purchase these goods will pay the company a certain amount of money which is the price of this particular product, but they are not just paying the company, but they are also paying the doctor or the healthcare system.

Why? The pollution that was created by the production of one extra pen is also causing a negative side effect on a number of people in their community who will have to pay for their own health costs because the company is not compensating them for the pollution.

Now, if we add that cost to the price that is actually paid for the purchase of one pen that is the social marginal cost. So, it is the private marginal cost to the producers plus any cost associated with the production of the goods that are imposed on the others, so that is the social marginal cost: the cost to the society of one extra unit of something. Now, that cost is paid to the company, and it is also paid to overcome the side effects of production.

In the case of a negative production externality, the social marginal cost is greater than the private marginal cost because there is a marginal damage that is also included. So, the social marginal cost is equal to the private marginal cost plus the marginal damage because the society is not just paying the private marginal cost, but it is also paying the marginal damage because of the use of this particular good.

So, MD here is the marginal damage. So, SMC or the social marginal cost is a private marginal cost plus the marginal damage. Now, why are we incorporating this private marginal cost? Because the society will be paying this amount for the production. Now, when we talk of production we are not just saying that the industry is producing things the society is also producing something.

Ultimately this is a decision that has to be taken by the society at large. Do we want pens to be manufactured by this particular process? Now, remember that we had said that a society's level of being or the living standards are decided by the amount of production in that particular society.

So, the society wants this particular good to be manufactured because it wants to raise the standard of living of the people who are living in this particular society. Now, to raise the standard of living, they will have to produce more. And when they are producing more, there is a cost involved in production and there is a cost of the marginal damage that is being made.

How does it look on the equilibrium curve? Now, this is our normal equilibrium curve. So, we

have a demand curve and we have a supply curve. And where the demand and supply are needed we have the equilibrium point that gives us the equilibrium price, and that also gives us the equilibrium quantity that is demanded or supplied by this market.

In the case of a negative production externality, if we do not consider the externality at all, then this curve will tell us the market equilibrium. So, here s is the private cost or the cost of production. Now, you will remember that the supply curve is given by the cost of production of the goods to the seller which is what we are seeing here. The cost of production is giving us the supply curve.

The demand curve is given by the private value that people are putting for this particular good. Now, in this example, the value is given by the amount a person is willing to pay for this particular pen. So, here we are observing that we have the private cost, and we have the private value that is giving us the demand and supply.

But when we consider the externality, then this private cost becomes the private marginal cost for each point on the curve. And there is a marginal damage that is also incorporated. And so we have a social marginal cost. Now, the social marginal cost at any point is the private marginal cost plus the marginal damage. So, the cost at this point plus the damage will give us the social marginal cost.

Because there is an increase in the cost because we are also looking at the cost of marginal damage. So, whenever there is an increase of cost, the supply curve shifts to the left which is what we are observing here. So, the supply curve in this case has shifted to the left. And the amount of this shift is given by the marginal damage that we have. So, in the case of the equilibrium considering the negative production externality, there is a shift in the supply curve.

Now, let us have a look at the benefits. Here we can talk about the private marginal benefit, and the social marginal benefit. Private marginal benefit is the direct benefit to the consumers of consuming an additional unit of the good by the consumer which means that as a buyer if I purchase this pen, what is the amount of benefit that I am getting is the private marginal benefit, the direct benefit to the consumers of consuming an additional unit of the good by the consumer.

And we also have the social marginal benefit, the private marginal benefit to the consumers minus any cost associated with the consumption of that good that is imposed on others. Now, in the case of the negative production externality such as manufacturing a pen with the polluting process, if I am purchasing a pen, I am not putting a cost on others by using this pen because the cost has already been imposed during the manufacture.

When I am using this pen and we in this case we are not talking about the pollution that will be spread, then I throw this pen out into the dustbin. But while I am consuming the goods, from the time that I purchase this pen and till the time I am writing with this pen, I am not imposing any cost on others because of this consumption.

If there is a cost that is involved, then we will have a difference between the social marginal benefit and the private marginal benefit. But in this case because it is a negative production externality only the social marginal benefit is equal to the private marginal benefit because no costs are imposed by the consumption of the good. So, in this case, the benefit curve and the demand curve is given by this D where private marginal benefit is equal to the social marginal benefit.

And there is a deadweight loss that is involved. So, what are we observing here? If we for instance take a quantity of this much, now what we are observing is that the benefit of this particular quantity of goods is given by this point where the quantity line the vertical line is intersecting with the demand curve. Now, the demand curve is giving us an indication of the value of this particular good.

It is giving us an indication of the welfare or the surplus that it will provide to the buyer. Now, in this case, the cost to the society is given by this point where the quantity curve which is the vertical line is intersecting with the social marginal cost curve. In this case, this is the benefit and this is the cost. So, it means that the benefit is greater than the cost.

So, the benefit is greater than the cost. Now, if we consider a point, say here, so this is the quantity that we are looking at Q. Now, at this quantity, the cost to society is this much. This is the cost to society. And the benefit to the society is given by this point, where it is intersecting with the demand curve and this is the benefit.

What we are observing here is that the cost is greater than the benefit. So, for this point, we have here we have cost greater than benefit. Now, in the case of economics, we had begun with our assumption that everybody is a rational decision maker which means that if the benefit is greater than the cost, then the decision to manufacture the good should be taken, but if the cost is more and the benefit is less than the society should not allow the manufacture of that particular good because it will cost the society more, but the benefit that the society gets is less.

Essentially, what we are saying here is that at this equilibrium quantity which is the optimal equilibrium quantity, this is the amount of goods that should be made or demanded or supplied, where the social marginal cost line is cutting the benefit line. But in actuality what is happening is that we are having this much amount of good that is being demanded or supplied, because this quantity we were getting when we were internalizing the externality.

This is the point which we are getting when we are not internalizing the externality. So, what is happening is that there is a deadweight cost involved. The deadweight loss is created for the society because some units are being produced and consumed for which the cost to the society is greater than the benefit to the society, or the social marginal cost is greater than the social marginal benefit.

This is the deadweight loss that gets created because of the negative production externality because for all of these units the cost given by the social marginal cost is greater than the social marginal benefit. So, this is the deadweight loss in the case of a negative production externality.

We can also have a negative consumption externality. When an individual's consumption reduces the well-being of others who are not compensated by the individual such as consumption of cigarettes. So, if somebody is consuming cigarettes, the people who are sitting around him or her are also becoming passive smokers, they will also suffer the health consequences of inhaling the smoke that is arising because our actor is consuming the cigarettes.

These people have got nothing to do with this person having the cigarettes, but they will have to suffer the consequences. So, it is a situation where an individual's consumption is reducing the well-being of others who are not compensated by the individual. So, in this case, the people who are becoming passive smokers and who will have to suffer the health consequences, they will not

be paid by the person who is consuming the cigarettes.

It becomes an uncompensated loss to others which is why it is a negative externality, and it is arising because of consumption. It is a negative consumption externality. Partying with a loud noise, now, in this case the people who are doing the party, they are having all the fun.

They are consuming the loud noise, but the consequences are suffered by the people who reside nearby because they do not want to have that loud music and a number of those people might also suffer because of the loud noise.

They will not be able to sleep properly if it is their sleeping time or they might suffer from certain health impacts. It is an increased hypertension. Now, this is a cost that the people who are doing the party are imposing on others and they are not compensating for it. So, they are not going to go to the others' homes, and pay the same amount for the cost of their treatment of hypertension.

Or consumption of SUVs - the sports utility vehicles. Now, these are large size vehicles that emit a large amount of pollution. So, they impose a cost on the society in terms of global warming, because they are consuming more fuel. And this fuel will get burnt and it will increase the amount of greenhouse gases that we have in the atmosphere. So, each SUV is doing a small bit to increase global warming.

Now, this cost is being imposed - the cost of global warming or the cost of climate change - is being imposed on the society by the people who are using these gas guzzling vehicles, but these people are not paying the society back or they are not compensating for the damages. So, it is an externality.

It causes damage to the roads because of a higher weight, but then these people are not going to pay extra for the maintenance of the roads. They lead to more insecurity to other vehicles due to their higher momentum. So, if there is an accident with two light vehicles, then the amount of damage that anybody suffers is less. In the case of an SUV because of its large weight, the momentum is higher.

And so the damage that it can cost to another vehicle is also higher. Now, this cost of the probability of having a higher damage is not being compensated by the owner or by the user of the SUV. So, this is a negative consumption externality. Now, in this case, again we can talk about the private marginal cost and the social marginal cost.

And the definitions are the same. The direct cost to the producers of producing an additional unit of the good is the private marginal cost. And the private marginal cost to the producers plus any cost associated with the production of that good that is imposed on the others is the socio marginal cost.

Now, in this particular case, we are not talking about the cost caused by the production of the SUV. We are only concentrating ourselves with the damage that is caused by the consumption of the SUV. And so in this case, we will say that the social marginal cost is equal to the private marginal cost because there are no costs that are being imposed by the production of goods.

We are not considering any cost in the production of the SUV, we are only concentrating on the cost of consumption, and so we will say that for our analysis SMC is equal to the PMC. Which means that when we talk about the equilibrium and when we are not considering the externality,

we have a private cost and we have a private value.

And in the case of the negative consumption externality, we are saying that the private marginal cost is equal to the social marginal cost. There is no change in the cost of production which means that there is no change in the supply curve. We are saying that there is no change in this green line.

On the other hand, when we look at the private marginal benefit and the social marginal benefit, the private marginal benefit is the direct benefit to consumers of consuming an additional unit of a good by the consumer that is the benefit that the person who is using the SUV is deriving out of using the SUV is the private marginal benefit. The social marginal benefit is the private marginal benefit to the consumers minus any cost associated with the consumption of the goods that are imposed on the others.

What we are saying here is that we have the social marginal benefit which is the private marginal benefit minus the marginal damage that is being caused by the consumption of an extra unit of SUV or by the consumption of an extra cigarette, or by consumption of an extra minute of loud noise. So, all of these are leading to marginal damage. And if we subtract that marginal damage from the private marginal benefit, we get the social marginal benefit.

What we are saying here is that the benefit to society in this case is not equal to the sum of the private benefit of everybody. It is the sum of the private benefit of everybody minus the marginal damage that this consumption has caused. So, if you look at the society in total, there is a benefit because of the use of the SUVs, there is a cost because of the use of these SUVs. And if you subtract the cost from the benefit, you get the net benefit which is the social marginal benefit.

In this particular case the margin because the social marginal benefit is less than the private marginal benefit. So, the curve will shift to the left. So, here we are observing that there is a change in the demand. And the demand is shifting to the left. And how much will this curve shift to the left is given by the marginal damage that is being caused by the consumption of an extra unit of this particular good.

So, we have a situation where the social marginal benefit is equal to the private marginal benefit minus MD. The social marginal benefit is less than the private marginal benefit and the difference is MD or the marginal damage. Now, when you have such a situation when the social marginal benefit is less than the private marginal benefit, then it creates a situation where you are having more amount of consumption than is the socially optimal level of consumption.

What do we mean by that? If we look at this curve and if we consider a point here, now the cost to the society is given by this point, the benefit to the society is given by this point. So, in this case, the benefit is greater than the cost. And for all the points to the left of this point, we will find that the benefit is greater than the cost. But at all the points to the right of this point, we will have a situation where the cost is given by this point which is there on the S-curve or the social marginal cost curve.

This is the cost, and this is the benefit that the society is getting. Now, in this case for all the points to the right of this point, we will have a situation where the cost is greater than the benefit. What does that mean? Remember that in economics we say that people are rational decision makers.

As a society, consumption of an extra good is leading to a cost which is greater than the benefit. In that case, that amount of goods should never have been produced because by not producing that good or by not consuming that good, the society can increase its total surplus.

The aim of the market was to enhance the social surplus of all the buyers and of all the sellers together. But, in this case, we are observing that we are consuming certain goods for which the cost is greater than the benefit. This leads to a deadweight loss situation.

A deadweight loss is created for the society because some units are being produced and consumed for which the cost to the society exceeds the benefit to the society. So, the social marginal cost is greater than the social marginal benefit.

And the quantum of this grade weight loss is given by this gray colored triangle. The actual social optimum quantity should have been this much, but the quantity that is being produced is given by this point when we are not considering the externality. All of these gray portions become deadweight loss.

We can also have situations of positive production externality. Positive production externality occurs when a firm's production increases the well-being of others, but the firm is not compensated by those others. Examples: a firm digging canal is paid for digging, but also benefits the farmers.

When they give a firm a contract to dig a canal, then we will only pay the firm on the basis of the amount of earth work that the firm is doing. The amount of earth that it has dug and removed to create the canal is the amount that we are going to compensate the firm.

But when the canal is dug then it also increases the agricultural productivity of the surroundings because now people have more water for irrigation of their crops. Now, this has an effect on the bystanders - in this case the bystanders are the farmers of the surroundings.

Now, those farmers were not paying for the digging of this canal, they did not pay the firm. But they are reaping out the benefits because of the action that the firm did. And the firm did not receive any compensation for the benefits that it provided to the farmers. This is an example of a positive production externality. It is positive because it is providing a positive impact on the bystander.

It is a production externality because this externality arises because of the creation of something, the production of the good. So, this is a positive production externality. Now, when the firm income increases, the standard of living in the surroundings may increase which will then also reflect in the nutritional status of children.

It will reflect itself in the educational status of the surroundings. Now, all of these positive benefits are being provided for by this company, but it is not receiving any um compensation for these positive impacts so which is why this is a positive production externality.

Another example is a firm that is doing mineral exploration because it also paves way for other firms once the mineral is found. In this case, there is a firm that is doing mineral exploration, and it is being paid for only the amount of exploration that it does, that is it is being paid for how many square kilometers of area it has explored.

But when there is the discovery of an important mineral in that area and important ore in that area, then it will also result in huge amounts of employment because there will be other firms

that will come to this area once the ore has been found. And they will extract this ore and in the process, they will also provide a large quantum of employment.

Now, the firm that was doing the exploration is not getting paid for the development of a surrounding that will happen if it is able to find out an ore so which is why this is a positive production externality it is bringing in a positive impact in the terms of employment or in terms of the total production of a country or in terms of the living standards in a country. So, these are the positive impacts that are being brought about by the firm that is in mineral exploration.

And this is a production externality because it has got nothing to do with the consumption aspect. The firm is only doing a production activity in terms of the service that it is providing. But because of this production it is giving a positive impact on the bystanders that is to say the people who will get jobs because of the extraction of these minerals, and the firm is not getting paid for that it is not getting compensated for that which is why it is an externality.

In such cases, we can talk about the private marginal cost and the social marginal cost. Now, private marginal cost as we have seen before is the direct cost to the producers of producing an additional unit of a good which means that in the case of the firm that was digging the canal, it is the cost of how much does it take to say dig an extra kilometer of the canal.

The direct cost to the producer is the direct cost to the company that is digging the canal of producing an additional unit which is say 1 kilometer of the canal. Then we also have the social marginal cost. The private marginal cost to the producers plus any cost that are associated with the production of the goods that are imposed on the others.

Now, in this case, the positive in the case of positive production externality we have social marginal cost equal to the private marginal cost plus the cost of production of goods that is imposed on others, in this case this is a negative figure. So, we get SMC is equal to PMC minus the marginal cost or plus the marginal benefit.

What we are saying here is that the social marginal cost is equal to the private marginal cost plus the marginal cost that is imposed on others. In this case, the cost is negative because it is a benefit, it is actually not a cost. So, this becomes a private marginal cost minus the marginal benefit that this production is providing to others. So, SMC is PMC minus the marginal benefit.

In this case, the society has to pay less of a cost because it is paying for the cost of taking minus there should be also a deduction for the benefit that this activity is given to the society. For instance, if I were to purchase this pen, and I am paying 30 rupees for the purchase of this pen, but I am getting 10 rupees back. So, in that case, the cost that I am paying for this pen is 30 rupees that I am paying minus the 10 rupees that I am getting back in the form of the benefit.

The social marginal cost in this case is the private marginal cost minus the marginal benefit. So, how does that affect the equilibrium? So, this is our normal equilibrium. And when we are not considering the externality, we are only talking about the private cost and the private value. But, in this case, the cost to society is less. The social marginal cost is equal to the private marginal cost minus the marginal benefit. It is costing society less to manufacture this good.

Now, if you look at the benefit or the demand side, then we have the private marginal benefit and the social marginal benefit which is what were defined as before. But, in this case, there is no cost that is imposed by the consumption of the good. So, if the society is consuming an extra

kilometer of the canal, then there is no cost involved in consuming the canal or in getting water from the canal.

In this case, the social marginal benefit is equal to the private marginal benefit because there is no change in the demand curve which is what we are showing here. What is happening in this case is that the society is paying for the taking of the canal, but it is also receiving a value in terms of the positive externality that is accruing because of the taking of the canal.

So, the society paid 30 rupees, but it got 10 rupees back in terms of the other benefits. Another example is if I purchase this pen for 30 rupees, I get this pen which is worth 10 rupees free with it. So, the cost that I am paying for this pen is 30 rupees minus this 10 rupees is what we are saying here.

The social marginal cost reduces by this amount of marginal benefit, but there is no change in the social marginal benefit because of an extra unit of the canal. So, the demand curve remains the same. The supply curve shifts to the right. Now, why is it shifting to the right? Because it is costing society less to manufacture the canal. So, if the cost of production goes down, then the supply curve shifter shifts to the right.

Now, in this case as well we can observe certain deadweight loss. A deadweight loss is created for the society because some units are not being produced and consumed for which the benefit to the society exceeds the cost to the society which means that if we consider the externality then the optimum quantity is this much where the red curve and the demand curve are intersecting.

But when we do not consider the externality, the optimum quantity is given by this intersecting point. So, these products from here to here are not being manufactured. Even though for each of these the cost to the society, say, if we consider a point here the cost to the society is this and the benefit to the society is this.

So, we have a benefit that is greater than the cost, but still we are not manufacturing this because we did not consider the impact of the positive externality. So, this is a deadweight loss given by this gray colored triangle. Then we also have a positive consumption externality. When an individual's consumption increases the well-being of others but the individual is not compensated by those others.

The individual is consuming something. This is a consumption externality where an individual is consuming something, but through it his or her consumption there is also an increase in the society's well-being or in the well-being of a bystander which is why it is an externality. And this is a benefit, so it is a positive impact. So, it is positive consumption externality, externality.

Examples include vaccination because they stop the spread of infections to even those people who are not getting themselves vaccinated. Or education of children because when children are educated when people in a country are educated, then it also has benefits to all the members of the society in terms of not just a better political thought process, but also because these educated people will probably later on start other industries that provide jobs to more people.

So, education is also a positive consumption externality. But then the society in most cases does not pay for this education, there are very few instances in which education is subsidized by the society. Now, when the society subsidizes, then it will become internalization of the externality, but it hardly happens.

Or, landscaping of one's garden. If you keep your garden clean, if you keep your garden landscaped, then that increases the value of the property of others in the society as well because it looks like a more beautiful society to live in. But then others do not pay you for landscaping your garden. So, this is a positive consumption externality because you are consuming by having a better garden, so that is your consumption. It is causing an externality which is positive.

So, it is a positive consumption externality. Now, in this case, because we are only considering consumption, the cost of production or the supply curve will not change which means that SMC is equal to PMC as before. So, this is the equilibrium not considering the externality. So, we have the private cost and we have the private value.

Now, in the case of positive consumption externality, there is no change in the cost of production. So, there is no change in the supply curve. The supply curve remains as before which is given by S is equal to PMC is equal to SMC . But, in the case of the demand curve, we have the social marginal benefit is equal to the private marginal benefit plus a marginal benefit that this externality is providing.

The society is getting this extra benefit from this activity or this good that is being consumed, and so the total benefit of the society increases. When that happens, we can observe that there is a shifting in the demand curve that should occur towards the right given by this difference of marginal benefit.

Once this happens, what we can observe is that earlier this much amount of equilibrium quantity of goods was being produced, whereas, if we internalize the externality, this much amount should be produced. Because if we consider any point in between let us say this quantity, now at this quantity the benefit is given by this point. This is telling us the amount of benefit that the society is getting. This is telling us the cost to society.

Now, if benefit is greater than the cost, then this good should have been produced, but what is happening is that because we are not considering that into the equation. We are not producing these or consuming these quantities. So, a deadweight loss is created for the society because some units are not being produced and consumed for which the benefit to the society exceeds the cost to the society. And here the deadweight loss is given by this curve in gray color.

To summarize, the externality is the uncompensated impact of a person's actions on the well-being of a bystander. And we have four different kinds. We can have negative or positive externality, and we can have production, or consumption externality.

That is all for today. Thank you for your attention. Jai Hind!

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Module 8
Public sector and Conservation
Lecture 2
Public goods and common resources

Namaste! We carry forward our discussion on Public Sector and Conservation and in this lecture, we shall explore public goods and common resources. Let us begin with a recap. We saw that externality is the uncompensated impact of one person's actions on the well being of a bystander. Now, externality is going to be a very important factor in this lecture as well. Externality is the uncompensated impact of a person's actions on the well being of a bystander.

So, somebody is doing something, but that action is also impacting other people who have got nothing to do with that decision or that action and they are also not getting compensated for those impacts in that case we say that it is an externality, and it is of four kinds, you can have negative or positive externality.

In the case of negative externality, the bystander is negatively impacted. In the case of positive externality, the bystander is positively impacted, that is he receives a benefit. Production externality occurs when the actor is producing something such as the mining industry and consumption externality occurs when the actor is consuming something so, it is a polluting vehicle.

When you have externalities and there isn't an uncompensated impact on the bystanders, how do you deal with them? So, we have different options to compensate for the externalities. They include public sector solutions and the private sector solutions. One solution is the use of regulation.

Regulation means that the government says that dumping waste into a river is a crime. So, if anybody is dumping the waste, then he or she is going to be jailed. Now, this is one way of ensuring that the rivers do not get polluted. So, by means of laws and by means of enforcing those laws, we ensure that the rivers do not get polluted so that the bystanders are not negatively impacted. So, this is one way: regulation.

Another is corrective taxes. A tax designed to induce private decision makers to take into account the social costs that arise from a negative externality. Now, corrective taxes also go by the name of Pigouvian taxes. Now, corrective taxes or Pigouvian taxes are a tax designed to induce private decision makers to take into account the social cost that arise from a negative externality. It means that if there is a negative; a negative externality, the government is going to put a tax on such an action so that it becomes more expensive to do that action that is having a negative externality. That is the use of corrective taxes.

An example is corrective taxes for pollution. In this case, what is happening is that we have a price for pollution and we have a quantity of pollution and there is a demand for pollution or a demand for pollution rights.

What this curve is telling us is that there are certain industries who want to be able to pollute the environment because say there is a factory and when the factory is run, then it would give out certain amounts of a smoke or if the machines are running, then it would give out certain amounts of noise.

The thing here is that the person who is owning this firm or the factory wants to make this pollution because by making this pollution, he is earning something, he is earning a profit so, he requires the right to pollute the environment with sound pollution, air pollution or any form of pollution, but then the demand for these pollution rights, this is also like any other demand for any other good in the market. So, there is also a price involved.

If you tell the factory owner that ok, you can pollute the environment if you pay 10 rupees for it every day, then probably the factory owner would say ok this is a small amount, what do I have to do with it. I will pay 10 rupees to the government and I will pollute as much as I want. But then, if the government says that ok, if you want to pollute, then for every unit of the pollutant that you are releasing, you will have to pay 50000 rupees.

Now, this person would start to think ok, am I earning enough to be able to buy this pollution permit for 50000 rupees probably not and if I am not earning enough money by running this industry and polluting the atmosphere, then probably it does not make sense for me to buy this pollution permit. His demand would reduce. If the price is too high, then probably the demand would be obliterated which means that at a very low price, the demand for pollution rights will be very large.

When price increases, the demand would reduce. Probably some people would want to reduce the amount of pollution that they are spreading by installing a pollution controlling device, but when the price increases very much, the demand will be very little. So, we are observing the law of demand that as the price increases, the quantity demanded reduces.

In this case, what the government is doing is that the government is setting up a price through this corrective tax. If this price is increased or decreased, that is what we are saying is that if the price is set at this point so, this would be the amount of, this would be the quantity of pollution that will be demanded. If the price is kept very low, then the quantity demanded will be very high.

This will be the quantity that is demanded. At this lower price, when the price is low, then greater quantity is demanded, when the price is high, then a lesser quantity is demanded. In this way, by setting a price through the corrective taxes, the government can regulate the quantity of pollution that is being spread into the environment.

Pollution is an externality because the factory owner is earning the benefits, he is earning the profits, but the people who live in the surrounding have to bear with this pollution and they have to pay the cost specially, the health cost, the cost of living in a polluted environment, the cost of having to bear with all the smell.

Because this is an externality, the government may make use of this corrective tax and in this

case, the government is not putting this tax to earn revenue. Now, this is the most important concept here. The government is not putting this corrective tax so that it can earn more revenue, the government is only putting this corrective tax to deter people from polluting.

This tax is only acting as a disincentive to the factory owners from polluting and similarly, the government can use these corrective taxes to control any behavior that has a negative externality. So, if the government thinks that ok, if people smoke, then the; then the people who are there in the vicinity become passive smokers and they have to bear the health cost.

So, what will the government do? The government can increase the price of cigarettes and how will the government increase the price of the cigarettes? By putting a corrective tax on cigarettes. In this case, the government is setting the price and the price is determining the quantity.

Another thing that the government can do similarly is to use corrective subsidies. In the case of corrective subsidies, the government provides money to certain activities that need to be promoted such as things like education or vaccination or health care.

When a person is vaccinating himself or herself, then they are also protecting the community from the spread of diseases. If people are more educated, then they are not just serving their own interests, but they are also serving the interest of the society by becoming more enlightened citizens.

These sorts of activities that have positive externalities, they are subsidized by the government as a solution of this externality. Another option with the government is to use things such as tradable pollution permits.

In the case of pollution permits, what happens is that the government sets the amount of pollution that can be done. In the previous case, the government was setting a price and this price was regulating the amount of pollution that will be released into the environment. In the case of tradable pollution permits, the government sets the quantity of pollution that can be spread.

In this case, what happens is that the government will give out certain permits and with each permit, a person is allowed to emit a certain amount of pollution. Let us say that there is a pollution permit and with each permit, a person can release 1 ton of carbon dioxide and the government what it is doing now is that the government is saying that ok, if you want to emit carbon dioxide from your factory, you will need a permit, but we are only going to issue 10 permits which means that a maximum of 10 tonnes of carbon dioxide can be emitted.

Now, what happens? Here as well, you have the demand curve for the pollution rights. But now, the quantity has been set and once we have the quantity, this quantity will determine the price that the people will be ready to pay for these pollution permits. Now, these pollution permits can be sold through an auction.

When these 10 pollution permits are sold through an auction, then those people who have the highest demand for these pollution rights, people who pay who have a very high amount of value to these pollution rights, they will be buying these pollution permits at a higher price and those people who do not put a very large value or who do not want to shell out that much amount of money, they will not get the pollution permits.

The government can even go one step further by stating that let the private parties also trade these pollution permits amongst themselves. What happens in that case is suppose there are 10

firms, and the government has sold 1 tonne permit to each and suppose 1 permit is costing rupees 1 lakh. We have these 10 firms A, B, C, D, E, F, G, H, I, J so, these are the 10 firms, and they all have the permit for 1 tonne of carbon dioxide emission.

But what now happens is that this firm G, thinks that 1 tonne of permit is not enough for me probably, I would want to go for 1.5 tonnes. Now, in this case, because it has a permit with itself only to emit 1 tonne of carbon dioxide, if it emits 1.5 tonnes of carbon dioxide, it will be penalized probably, the owner might go to jail.

Now, the option with this firm G is that it will ask everybody else in the market whether anybody has an excess of the permit as compared to their requirements. Suppose firm B bought 1 tonne permit, but it is only going to need 0.8 tonnes when it is doing its production. In this case, it can sell off 0.2 tonnes that remains to this firm G.

What is the rate at which it will be selling these 0.2 tonnes? It will not be this rate, at this rate, it would have costed only 20000 rupees, but now that firm B knows that firm G desperately needs these pollution permits probably, it is going to sell them for a bit more. So, in place of 20000 rupees probably, it will be charging it say 25000 rupees.

Because G desperately needs more pollution permits, it will be ready to pay say 25000 rupees, but then, when these pollution permits are getting traded, then this will also result in certain impacts on the other firms. Probably, firm I will think that ok, I have this 1 tonne permit and I bought it for 1 lakh of rupees, but now the price has appreciated so, from 20000, it has increased to 25000 so, there is an increase of 5000 every 20000 is 25 percent increase in the price.

Now, firm I will think that ok, I have this thing that is worth 1 lakh of rupees, that is I have paid 1 lakh of rupees for it, but I can sell it off for 125000. So, let me figure out if there is a way that I can reduce the amount of pollution in my firm so that I am also left with certain excess. That is because the price has increased in the market because of free trading so, now, this firm will also try to reduce its emissions.

In this case, the government is not forcing this firm to reduce the emissions, but what is happening is that because of the market mechanism and looking at everyone's self-interest, now in this case, the firm I is not thinking that if I am releasing pollution, then it is harming the environment or it is creating an externality to the people in the surroundings no, they are only looking at their own self-interest and in this case, firm I is thinking that if I can reduce my amount of emission, then probably I can sell my permit at a premium.

Probably it will also try to cut down its pollution and so, in place of say emitting 1 tonne of carbon dioxide probably, it is able to; it is able to bring it down to 0.9 tonnes and in that case, it can sell the remaining 0.1 tonnes to the firm G. So, what is happening in this case is that the government is not putting a price to the pollution as it was doing earlier.

Earlier the government was setting the price through means of taxation. In this case, the government is just saying that ok, this is the amount that we are going to permit and whoever has a higher requirement, whoever values the right to pollute more is going to pay more and if there is still a shortfall.

We can even permit the players to trade amongst themselves, the government only needs to enforce the rules to see to it that nobody is able to pollute without a permit and the market mecha-

nism will take care of everything else. Now, in this case, we have a solution to the problem of externality. The government wanted to reduce the externality in the form of pollution and this is one way of doing it.

The government may go even a step further. The government may say that ok, this year we permitted 10 permits, but next year we are going to permit only 9 so, when there is a gradual reduction in the number of permits that will be issued, then slowly and steadily, those firms that are in a better position to cut down their pollution, they will take hold of this opportunity and cut down their pollution.

In this case, not every firm is cutting down its pollution because there could be certain firms such as a cement firm that has little options to cut down on the amount of carbon dioxide that it releases because during the production of cement, calcium carbonate has to be heated and that will release carbon dioxide.

There is a limit to which it can bring down its carbon dioxide emissions, but at least those firms, say a firm that is working in the energy sector, may at least bring a few of its coal-based power plants down and probably shift to solar energy or wind energy.

So, those firms that are in a better position to cut down on pollution will do so and they will trade these pollution permits with those firms that are not that good at reducing their pollution and slowly and steadily, the government can control the amount of pollution. So, this is another way in which the externality can be regulated.

Other solutions are the private sector solutions. Moral codes and social sanctions: social boycott of those who are doing pollution. So, in this case, the government is not needed, but what is happening is that the society is boycotting these firms that are doing pollution and probably the society is encouraging those people who are cutting down the pollution, showing an exemplary way of cutting down pollution.

Another option is charities, giving money to those organizations with positive externalities. Schools and colleges and research institutions. This is another way in which the government is not needed, but if people in a society find that research institutions are good for the society because they are going to increase efficiency, they are going to lead to better health care, better education.

In that case they can themselves provide a certain amount of money to these institutions. Integration of businesses such as orchard and apiculture together to reap maximum benefits, contracts and bargaining. So, these are all different solutions to externalities.

And here we also looked at the Coase theorem. The proposition that if private parties can bargain without cost over the allocation of resources, then they can solve the problem of externalities on their own. Now, this is something that we have seen before, but the important thing in the Coase theorem is that it does not matter who has the upper hand whatever be the situation, the private parties can come to a solution to the externalities, and they are able to bargain without cost.

Let us look at the case of a steel plant that is polluting the river and this pollution is reducing the fish catch. Now, here again for the Coase theorem to work properly we need to have property rights and we need to have a government that can help in the enforcement of property rights. We will look at two cases.

The 1st case is that the river belongs to the fishermen. The government has given the right of the river to the fishermen. So, they exert a right on clean water, and they threaten to close the steel plant. Now, in this case the fishermen go to the steel plant owner and say that ok, this river belongs to us, you cannot pollute this river, if you do this, we are going to enforce our property rights and we are going to shut you down.

Now, in this case, when both these parties can bargain together, the steel plant owner can tell these fishermen that ok, your catch is getting reduced because I am spreading this pollution, but then, there has to be some rupee value or dollar value to the amount of cash that does not go down.

What he is saying is that suppose earlier, you were earning 20000 rupees because of your fishing operations, but because of my pollution, now, you are earning only 10000 rupees and because you are earning 10000 less so, you are telling me that you are going to close the plant, but I have a better solution. So, the steel owner says that let me pay you 11000 rupees and you let my plant to work as before.

In this case, the the plant owner is at a profit because probably, he is manufacturing a steel that is worth lakhs of rupees and he only has to pay 11000 rupees and the fishermen are also at a benefit because earlier, they were earning 20000 rupees, now they will be earning 10000 rupees from fishing and getting 11000 rupees as compensation. In this way, through bargaining, both these parties can come to a solution that can benefit both of them.

Another option is when the river belongs to the steel plant. Now, in this case, the fishermen are concerned about the reduced catch so, what is happening is that the fishermen, they find that their catch has gone down by 10000 rupees and because the steel plant owner is also owning the river, he can pollute as much as he wants. So, now, what these people will do is that they will tell the steel plant owner that we are going to pay you something.

What they will say is that we are going to pay you say 5000 rupees to install pollution control equipment. What the fishermen are doing in this case is that the plant owner because he owns the fish and he is in no mood to pay for the cost of installation of the device, what the fishermen would do is that they will install the device for the plant owner and in this case, the machine is going to bring down the pollution.

What is happening here is that they can either install the equipment or they can pay to the steel plant owner and say that ok, you please reduce the amount of pollution that you are causing, and we are going to pay you for that. So, you give us this service of reducing pollution and we are going to pay you for the service.

What we are observing here is that whether the river belongs to the fishermen or whether it belongs to the steel plant owner, in both the cases, the parties can bargain amongst each other and come up with a solution, that is the beauty of the Coase theorem. Whether the property belongs to any one party, the both the parties if they are able to bargain without cost over the allocation of resources, they can solve the problem of externalities on their own.

Essentially, what we are saying here in the case of externalities is that markets are usually a good way to organize economic activity because as we have observed people can do trading of pollution permits, people will go with Coase theorem and solve the problem of externalities, but if that

does not happen another option is that governments can sometimes improve the market outcomes as in the case of corrective taxes.

Other kinds of goods are public goods and common resources. Let us look at this case: The village that Shyam lives in is surrounded by grasslands. The grassland can support 200 cattle. Each person in the village has a right to graze his or her cattle in these grasslands which means that there is no private property as far as grasslands are concerned, any person can take their cattle to the grasslands for grazing.

The village has 20 people, each of them have 10 cattle which means that the total number of cattle is 200 and the grassland can support 200 cattle. So, basically the grassland can support 200 cattle and there are already 200 cattle in the village and Shyam is thinking of buying one more cow. What is his cost in benefit given that the grassland is already supporting the maximum number of cattle and will he buy?

Essentially, there is a grassland, and the grassland can support 200 cattle, there are already 200 cattle, and we have one person in this village who is thinking of buying one more cattle. Now, in economics we consider that people are rational thinkers. Now, if Shyam is a rational thinker, what would he think? He would think that ok, if I get one more cattle, then the total number of cattle will be 201, but the grassland can only support 200 cattle.

Now, the grassland is not an entity that will only permit 200 cattle to get inside and will leave out one cattle, but what will happen is that each of these 201 cattle will be eating a little less. In this case, suppose one cattle can give 10 liters of milk. Now, every cattle because they are getting less amount of feed so, every cattle will be giving out less amount of milk.

Let us say that every cattle in place of giving 10 liters of milk will give 9.8 liters of milk, but then the one cow that I am going to bring that is also going to give me 9.8 liters of milk. What it means is that earlier, Shyam had 10 cows and each of them was giving 10 liters so, in total it is 100 liters of milk that he is getting.

With one more cattle, he will be having 11 cattle and each of them will be giving 9.8 liters of milk. What is the total amount of milk that will be produced for Shyam? It will be 107.8 liters. Now, the thing here is if Shyam only kept 10 cattle, he was getting 100 liters of milk.

But when Shyam gets the 11th cattle, he is now getting 107.8 liters of milk which means that his production has increased by 7.8 liters and the cost of having this cattle is being borne by all the other people because they will be getting a slightly less amount of milk.

Now, this kind of a resource is known as a common resource. So, this is a common property, there is no private property rights in this grassland and a common thing with common property is that people tend to over utilize them and remember that this sort of a thinking is coming from a rational decision-making process, it is not that Shyam is irrational.

Even though Shyam knows that 200 cattle is the maximum that can be supported, he would still want to have one more because it is in his own benefit. Now, in this case, we are not talking about an externality because it is having a negative impact on everybody else that is fine, but what we are talking about is what is the impact on the resource?

Now, when Shyam gets this extra cattle, he also knows that it is possible that because of overgrazing, the grassland itself will be destroyed, but then, the destruction of grassland will take

some time so, it will be a long-term process and in the long-term, we are all dead.

So, everybody is doing short-term thinking and so, Shyam will get one more cattle and we will have a similar thought process with every person in the village so, every person would want to have one more cattle, but when that happens, the overall common resource gets destroyed.

Another kind of resource can be understood with this example. The society that Ram lives in has decided to go for beautification and is collecting funds for it. In this process, the walkways will be cleaned and paved, and on both sides, trees will be planted. The contribution to this fund is voluntary. Will Ram pay to the fund or not because whether Ram pays to the fund or not, he will benefit from the beautified surroundings. Now, the question is will he pay?

Because the thing is when the society is beautified, Ram is going to have all the benefits of that whether he pays or not because once the society has been beautified, once the pavements have been cleared, once you have these trees, then Ram is also going to enjoy the benefits, there is no way that the society can say that Ram is not allowed to use this benefit, the society cannot say that ok, Ram you did not pay so, you should not walk in the shade of these trees and you should not be using the pavements, the society cannot do that.

Now, in that case, it is in the interest of Ram if you look at a short-term rational decision-making process. Ram will think that ok, I should not pay because whether I pay or not, I am getting the benefits so, why should I pay. But when that happens and this; this sort of rational thinking will be there in the minds of everybody. Every person who lives in the society will have a similar thought process because this fund is voluntary so, why should I pay.

But when that happens, when nobody pays for the fund, then probably the society will not be beautified and so, Ram and everybody else in the society will continue to live in a dirty looking surroundings without these trees, without clean pavements, but it is being done through a rational decision-making process and things such as these are known as public goods.

And these sorts of things, the public goods and the common resources are at the heart of lacking efforts to save the environment and over utilization of natural resources because when we talk about Ram living in this society, it is very similar to saving the environment.

So, the thing is if we conserve the tigers, if we conserve our forest, we are all going to reap out the benefits. Everybody is going to have the benefits of biodiversity, but when it comes to payment, nobody wants to pay for these.

People want to have more number of roads, people want to have more electricity, but then people also want more biodiversity, people also want to have tigers, people also want to have tourism in their country, but they do not want to pay for that because the thing is if you do not pay for electricity, you do not get electricity, it is something that you can be excluded from, but the benefits of biodiversity cannot be excluded.

If somebody pays or not, they are going to get the benefits of biodiversity. So, it is a public resource, it is a public good and similarly, when we talk about polluting the environment so, everybody knows that the environment can only tolerate a fixed level of pollution and if we cross this threshold, then it is to the detriment of everybody, but still people go on polluting why? Because the environment, air, and water are all public, these are all common resources.

Even though the quality goes down, the quality goes down for everybody so, everybody will suf-

fer. If everybody is going to suffer, but I am going to gain from it, why should I not pollute is the sort of thought process that goes on in the minds of people. Which is why public goods and common resources are very important topics when we talk about conservation economics. These are cases where completely rational thinking destroys the environment.

And we have observed a number of such cases such as things like the Minamata disaster in which Chisso corporation just dumped untreated mercury containing toxic waste into the seas. Now, it is not that the people from the Kiso corporation did not know that mercury is bad for the environment, the thing is if we pollute the seas, then the cost will be paid by everybody, but the benefits will be gained only by us. So, why not pollute? That is the sort of thought process that goes on.

The smog of London. Everybody knows that if we are using fuel to heat the homes and we are using those fuels that are releasing pollution, that will lead to negative consequences, but the thing is negative consequences will be borne by everybody. But if I am using this fuel to heat my home, even though it is giving out a huge amount of pollution, but then, I am getting the heat so, I am gaining the benefit, but everybody is paying the cost so, why should I not gain the benefit?

A rational decision-making in these cases destroys the environment. Things like the release of toxic uh gases like dioxin, the dumping of waste into the Love canal, the Bhopal gas tragedy, these are all questions of conservation and rational thinking lies at the heart of them. What are these common resources, what are the public goods? Essentially, we can divide goods into four different categories depending on whether or not they are excludable and whether or not they are rivals in consumption.

Excludability is the property of a good whereby a person can be prevented from using it. So, when we say that a good is excludable, it means that one person can say that no, you cannot use this good, this good is mine or this good is ours and we will not permit you to use this good. So, you as a person can be excluded from using it.

A very good example is your home. If an outsider whom you do not know wants to enter your home, you will just say no, we are not going to permit you inside. So, your house is an excludable good, you can exclude people from getting inside. Private societies are excludable goods, you can exclude people from getting inside.

Your personal resources are excludable goods because you can always say that the pen that you have, you are not going to others; you are not going to permit others to use your pen, you can exclude them from using the resource that is the pen that is in your hands. The other criterion is rivalry in consumption. The property of a good whereby one person's use diminishes other for people's use.

When we say rivalry in consumption it means that if I consume the good, then you have less amount or less quality of that good available for consumption. A good example again is things such as forest. So, if I cut down a tree, then that and I take the timber away, then that timber is not available for your reuse. So, it is a rival in consumption. If I use more, you get less. If you use more, I get less. That is rivalry in consumption.

And using these two criteria, we have four different categories. The first one is private goods. Goods that are both excludable and are rival in consumption. Clothes, cake, ice-cream, congested

toll roads. So, if I have a cake and if I eat up this cake, then less of this cake is available for you to eat.

So, it is a rival in consumption. The more I eat, the less is; the less remains for you, but it is also excludable. I can say that this is my cake, I am not going to allow you to eat it. So, it is excludable. Goods that are both excludable and rivals in consumption are known as private goods.

Another example is congested toll roads. Because the road is congested it means that if one more vehicle gets inside, if I take my vehicle inside this road, then it becomes a rival in consumption because you have less of the road available for use. So, essentially, if I get into this road, your speed also reduces. The more I use this road, the less it is available for others and so, it is a rival in consumption.

But at the same time, it is also excludable because it is a toll road which means that we can say that we are not going to permit other people to use this road, if they do not pay for getting inside. So, it can be excluded. We can raise the price of getting inside too high so that people effectively cannot use the road at all. So, it can be excluded. So, congested toll roads are also private goods. The second category is club goods. Club goods are those goods that are excludable, but they are not rivals in consumption. Things such as cable TV. Now, in the case of a cable TV, it is not a rival in consumption because if I have cable TV in my house and you have cable TV in your house and if I am using the cable TV, it does not stop you from using the cable TV, it does not reduce the quality that you are getting in your home, it does not reduce the number of channels that you get in your house.

So, this is not a rival in consumption. But it is excludable because the service provider can always say that if you do not pay so much amount to me, I am not going to give you the subscription. So, it is excludable, but it is not a rival in consumption. Things such as mobile subscriptions. Here again, if I have a mobile, you have a mobile, then both of us can use the mobile, but it can be excluded. So, people who do not pay the charges will not get the mobile subscription.

Fire protection: if my house is protected, it does not reduce the quality of protection of your house. If there is a fire and if we have a fire service, then you are also going to benefit I am also going to benefit so, it is not a rivalry consumption, but it is excludable because if a private company provides this service so, the company can always say ok, those people who pay for the subscription are going to get the fire services others are not going to get it.

Things such as uncongested toll roads. Now, here, it is a toll road which means that it is excludable. So, people can say that; that those people who are not paying the tolls will not be permitted so, it is excludable, but at the same time, it is not a rival in consumption because it is uncongested.

So, there are so few vehicles on this road at present that if a few more vehicles get inside that is not going to make any difference in the quality of usage by the people who are already inside. So, these sorts of goods are known as club goods.

Another category is common resources. Goods that are rival in consumption, but not excludable. Things such as fish in the lake. Now, fish in the lake is a rival in consumption because if I take out more of the fish, if I do more fishing, then less fishes available for you.

So, it is a rival in consumption, but it is not excludable in most cases because people have free

access to the lake. So, until and unless there is an authority that puts up a fencing all around this lake, it is not excludable, but it is a rival in consumption.

Things such as clean air, it is a rival in consumption because if I use the clean air and I pollute it in the process of using, then you will not get that amount of or that quality of clean air, but it is not excludable because one person cannot say that ok, this is my air, you are not; you are not permitted to use this air, it is there for everybody or congested non-toll roads.

Now, because this road is non-toll so everybody can use it, it cannot be excluded, but because it is already congested, the more people that get inside this road, that are using this road, the lesser the quality remains for the other people to use it. So, these are common resources.

Now, the issue with the common resources is the issue of the tragedy of the commons. A situation in which a shared resource where individual users, acting independently according to their own self-interest, behave contrary to the common good of all users by depleting or spoiling the shared resource through their collective action. It is a situation in which there is a shared-resource system.

So, the resource is shared which means that mean many number of people can use it and in this tragedy of commons, there are these individual users who are acting independently according to their own self-interest and they are also doing a rational thinking, but in doing this rational thinking and in acting in their own self-interest, they act in a matter that is contrary to the common good of all the users.

So, by acting in their self-interest, they act against the interest of all the people, of all the users by depleting or spoiling the shared resources through their collective action. Good examples are overfishing and overgrazing. In the case of overfishing, all the individual users or any individual user while acting in his own self-interest would think that I should have more and more fish, I do not care whether these fish are being removed in a sustainable manner or not.

The only thing that I care about is how much profit can I make, how many fish can I take out, but when everybody does this, then the whole resource gets depleted, but in this case, everybody is acting in their self-interest, everybody is doing the rational thinking, but still the resource gets depleted. This is the tragedy of the commons.

And we have looked at this example that everybody in this village would want to have one extra cow, but when everybody is acting in their own self-interest, through rational thinking, acting independently they destroy the whole of the resource. So, this is a tragedy of the commons.

Now, there are certain solutions to the tragedy of commons. Things such as social arrangements.

Now, in the case of the tragedy of commons, we said that individual users are acting independently.

Now, if we remove this term independently by putting in a social arrangement, now in this case, the social arrangement could say that ok everybody only gets 10 minutes to fish. Now, when you have such a social arrangement, then it is not possible for people to take out all the fish or for people to do all the grazing.

Basically what it says is that we have a grassland and in this village, we have 20 people all with 10 cattle and every person gets 10 minutes for their cattle to graze. Now, in this social arrangement what happens? If Shyam gets 11 cattle and he is only getting 10 minutes for these cattle to

graze so, what is happening is that in those 10 minutes because the cattle can only graze in a certain portion in this area so, his cattle will be getting less amount of fodder, but other people's cattle will be getting sufficient amount of fodder.

In such a social arrangement, we can ensure that people are acting in the benefit of the common resources as well. So, things can be regulated. Everybody getting 10 minutes for fishing with a specific size of net is again another social arrangement through which we can solve this problem or things like privatization.

In privatization, we can make this farmland a private resource. When it becomes a private resource, it becomes excludable and it becomes a rival in consumption. Now, it is already a rival in consumption, but by putting the clause of excludability, we can say that ok, if people have to bring in cattle inside, then for each cattle they will have to pay say 20 rupees. So, the people who are bringing in more cattle will have to pay more, this is another arrangement.

Or government regulation such as the UN convention on the laws of the sea. So, we can have regulation by the government as well about how these resources have to be managed. A very good example is the management of forests in our country. The supreme court says that a forest will be managed only according to a working plan and in the working plan.

The government makes a regulation about how many trees can be cut so that the extraction of timber happens in a sustainable manner, government regulation is a way to solve the problem of tragedy of commons. Another thing is internalizing the externalities such as tax on petrol which means that if because clean air is a common resource so, if the petrol is taxed higher so, in that case, the externalities are getting internalized.

The more one person is polluting by using a less fuel-efficient vehicle, the more they will have to pay. So, these are all different solutions to the tragedy of commons. Similarly, we have public goods. Goods that are neither excludable nor rival in consumption. So, you cannot prevent anybody from using this resource and these resources are not rivals in consumption which means that if one person uses this resource, then it does not reduce the quantity or quality of the resource or used by other people.

Good examples are things such as warning sirens. Now, if there is a siren that is blaring because a tsunami is nearby, then we cannot say that people who did not pay for this siren are not going to be permitted to hear it or if one person hears it, it does not reduce the quantity or quality of this resource for use by others because if one person is warned and other another person also hears it, he will be warned equally well.

Or things like national defense. Now, if the nation is defended, everybody is defended, you cannot exclude somebody. It is not a rival in consumption because as citizens of the same country, if my nation is defended, then it does not reduce the quality of defense of you or your nation because we both belong to the same nation.

So, national defense is a public good. Scenic view, if a view is beautiful, then we cannot prevent people from seeing it and if one person has seen a beautiful place, then it does not reduce the quality or the beauty of that place to be seen by other people.

Fundamental research, fighting poverty, uncongested toll roads now, uncongested non-toll roads. Now, these are all goods that are neither excludable nor rivals in consumption. In the case of un-

congested non-toll roads because there is no toll so, there is no restriction so, it is not excludable and because it is uncongested so, there are less number of vehicles that are applying and so, if a few more vehicles get inside, it is not going to reduce the quality. So, these kinds of goods are known as public goods.

Now, in the case of public goods, we have the free rider problem. Free rider is a person who receives the benefit of the good but avoids paying for it. So, this is a person who receives the benefit. Why does he receive the benefit? Because this public good is non-excludable, but in this case, he avoids paying for it. So, he is getting the benefits without paying the cost. So, he is a free rider, and a good example is this example of Ram who is not paying for the beautification of his society but is gaining all the benefits of it.

Now, there are a number of solutions to the free rider problem. One is public sector provisioning of public goods. So, in this solution, what happens is that the public sector or the government provides the public goods. So, when we talk about things such as national defense, then it is the government's rule to provide for this good. When we talk about uncongested non-toll roads, roads that are joining the villages that are in very distant areas, they are provided for by the government and the government gets money through taxation. So, in this way, this problem can be solved to quite an extent.

Or social norms sanctions, in this case, if we have a resource such as a warning siren. Now, in this case, the social norms and the sanctions may say that everybody should pay for the warning sirens to be installed and if a person does not pay for the; for the warning sirens, then probably this person will be ostracized. So, social norms and sanctions can help solve the free rider problem.

Also, if they find a person who is doing uh free riding, then there can also be a social boycott. So, in this way, the social norms and sanctions can be used, or the use of voluntary organizations such as the Red Cross. Now, this is similar to the government providing these services or we can have contracts or we can have a private sector that is providing the goods at a cost such as lighthouses charging nearby ports.

Now, in this case, what happened was that the lighthouses used to provide direction and used to give a signal to the boats or the ships that there is a port nearby. Now, if there was a ship that was not paying for the running of the lighthouses, then in that case, the ship cannot be excluded from seeing the light and also this uh, but is non-rival in consumption. But then, if this happens, if nobody wants to pay for the running of the lighthouses, then there will be no lighthouses.

In this case, the solution was that the lighthouses started to charge the nearby port. So, they used to say that ok, if ships come to your port, then in that case, there will be business going on in that port. If you do not pay us, we are going to switch the lighthouse off. Once that happens, the ships will not know that there is a port here and they will just bypass your port and they will go to another port.

And in this way, the private sector so, in this case, the lighthouses were being built and run by the private sector, but the private sector started charging and they used to charge in such a manner that they used to get the fund or integration of the potential free riders. A builder who is constructing a complete colony will not worry about free riders using these street lights since all the

land where the land where the light is falling is his.

So, streetlights are also public goods because you cannot exclude people from using them and they are non-rival in consumption, but if nobody pays for the streetlights, then what will happen? There will be no streetlights.

So, either the government can provide for the streetlights or the builder can provide for the streetlights and when the builder provides for the streetlights, then there is no issue of free riders because the land that is being lighted also belongs to the builder. So, in this case, the integration of potential free riders can solve the problem.

In certain situations, the free rider problem is very easily solved through private provisioning such as when some individuals care more than others because of their higher income or stronger taste for public goods. So, a rich person may pay for getting his surroundings clean, irrespective of whether poor people in the surroundings pay for it or not.

In this case, the public good will be made available by the rich person for the use of everybody because he cares so much about his clean surroundings that he does not care about whether others are paying for it or not. This is one case. Another is the case of altruistic activities. When individuals value the benefits and cost to others in making their consumption choices.

Example is when people trust others. If there is a person who trusts everyone or if there is a society where everybody trusts everybody so, in that case, the free rider problem will not be there because of the trust, because of an ingrained social value, the free rider problem will get solved by itself.

Or the warm glow model, a model of the public goods provision in which individuals care both about the total amount of the public good and their particular contributions such as getting publicity by doing social work. Now, in this case, the public good is being made available through social work because people feel good about doing the social work. So, these are three cases where the private provisioning or free rider problem can be done.

Now, there is one issue when we say that the public sector can provision for the; for the public goods, one is that they can be crowding over which means that as the government provides more of a public good, the private sector will provide less, and this will lead to a contraction of the private sector. Now, if you want a free-market economy, if we want a capitalist sort of a system, in that case, crowding out will become a serious problem.

But then, the solution is to contract out. An approach by which the government retains the responsibility for providing a good or service but hires private sector firms to actually provide the good or the service such as government hiring private firms for cleaning of localities and paying them through the tax revenues.

In this case, the private sector will be working because they are actually doing the cleaning operation, but because the government is acting as an intermediary by paying them through the tax revenues so, in this case, the free rider problem gets solved automatically because the government ensures that these private sector firms get money for doing the work. So, this is an option.

In summary, we have these four kinds of goods determined by whether they are excludable or not and whether they are rivals in consumption or not.

That is all for today. Thank you for your attention. Jai Hind!

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Module 8
Public sector and Conservation
Lecture 3
The design of the tax system

Namaste! We carry forward our discussion on Public Sector and Conservation and in this lecture, we shall have a look at The Design of the Tax System. Now, we know that governments spend money on conservation or things like environmental protection and in certain cases, the total amount of spending is pretty substantial. So, countries in the European Union spend like 1.2 to 1.4%, in some cases less, in some cases more of their GDP, a percentage of their GDP into environmental conservation.

If the GDP is large, the total offset for conservation also becomes large. Similarly, when we look at the sustainable development goals, then the world spends to achieve those sustainable development goals. In our country, this news article says the environment ministry gets rupees 3100 crores in 2020-21 of which 460 crores were allotted to control pollution. Now, the thing is 3100 crores is not a small amount. The question is where is the government going to get this money from?

Similarly, this article says in the Karnataka budget, we have a survey of the shola forest to conserve diversity and we have observed in one of the earlier lectures that the shola forest are a very unique ecosystem in which we have grasses and we also have the trees and they are in a dynamic equilibrium. Now, because these are very unique ecosystems, they have certain specific requirements and the governments are paying key to those requirements. But then, where is the money going to come from or this one?

As the government plans to use 75 percent of MGNREGS Work to Conserve Water. So, what the government is doing is that it is using this scheme of MGNRDEGS for water conservation, which means that a particular portion of the budget is being used for conservation purposes.

In this case form is the conservation of water. Government sanctions 305 projects for clean Ganga Mission. Here again, we are spending money on the cleaning of the Ganges river. Clean Ganga mission gets a boost. Varanasi sewage plant to clean 14 crore litres of wastewater every day.

In this case, the government is using money to set up a sewage plant and the sewage plant is going to perform water treatment. Now, this is important for conservation. But here again, all these things require money. Forest department to set up the world's first mangrove zoo at Jharkhali, all of these requirements. And this money comes primarily from taxes, which is why a study of

taxes is very important for the study of or for the implementation of conservation.

Because we are getting money for all these conservation activities, primarily from taxes. So, it becomes important to know what taxes; what are the pros and cons of the tax; how should the government decide how much amount of tax to impose on people; who is going to pay the taxes; are the rich people going to pay the taxes or are the poor people going to pay the taxes or are we going to have a system in which everybody pays the same amount of tax; how do we decide between these things.

Because these are important, they have important ramifications for conservation. So, we need to understand them in the context of conservation economic system and the most important point about taxes is that taxes have deadweight losses. So, to review what we saw earlier was that when the government imposes a tax only on the sellers. So, in that case, the government can say that whenever there is a sale of a good, then the seller will have to pay such and such amount on every sale to the government as taxes. Now, when that happens, the cost to the sellers to sell the good increases, which is shown by this left shift. So, the supply curve is shifting to the left and the amount of the shift is given by the amount of the tax. So, more the tax, more is the shift.

Now, even though the government is imposing this tax only on the sellers, what we are observing is that this tax is getting distributed between the buyers and the sellers which means that earlier, we were having this equilibrium. So, this was the natural demand and supply equilibrium which was giving us the price without the tax and it was giving us the equilibrium quantity that was demanded or supplied by the market. Now, the supply curve shifts to the left because of the tax.

This is the new equilibrium. This is the price that buyers have to pay to get the goods and because of this left shift, we also observe that there is a reduction in the quantity that is demanded or supplied. So, essentially what is happening in this case is that the market has shrunk. The market has reduced in size because now, there are lesser goods that are demanded and supplied in the market; now, that is going to have an impact on the society.

So, even though the government is taking this money from the sellers, one of the reasons to have this money is also conservation. So, the government is taking this money from the people, in this case only the sellers for the conservation purposes; but this is leading to a shrinkage in the market and the price that the sellers get can be figured out by drawing a vertical from the equilibrium with the tax, it cuts the supply curve here. So, this is the cost of making the goods and supplying the goods by the sellers.

This is the price that the sellers pay. And even though the tax was imposed only on the seller, this tax gets divided. This is the seller's share, which is the price without the tax that they were getting minus the price that they are getting when the tax has been imposed.

This is the seller's share and we also have a buyer's share which is the price that the buyers are paying now minus the price that they were paying without the tax. So, in short, what is happening here is that even though a tax has been imposed only on the sellers, we are observing that it gets distributed between the buyers and the sellers and the market shrinks. There are now lesser quantities of goods that are demanded and supplied in the market.

A very similar thing happens when the tax is imposed only on the buyers. Now, when the tax is imposed on the buyers, the demand curve of the buyers shifts to the left. Because now things are

becoming more costly, because people will now have to pay more; because they will not have to pay just the seller, but they will also have to pay the government in the form of the tax. So, in this case, the demand curve is shifted to the left.

The supply curve remains the same and here again, we observed that this is the normal equilibrium, the equilibrium without the tax and this is the new equilibrium. Now, in the equilibrium without the tax, this was the quantity that was demanded or supplied and this was the normal market price.

When the equilibrium shifts, then a lesser quantity is demanded or supplied. So, what we are observing here is that when the tax is imposed only on the buyers, then also the market shrinks; lesser quantity of goods are now demanded and supplied in the market and another thing that happens is that the price that the sellers will get is given by the point, where this new demand curve is cutting the supply curve. Now, the supply curve in this case does not shift.

So, this is the price that the sellers pay. And to get the price that the buyers must pay, we can draw a vertical and this vertical cuts the demand curve at this point and this is the price that the buyers will have to pay. What is happening here is that when the government is putting a tax only on the buyers, then the buyers will have to pay this amount to the sellers and the buyers will have to pay a certain portion to the government so that the total price that they have to pay is much higher.

Now, here as well the tax burden gets distributed because the new price that the buyers have to pay is this, the price they were paying before was this. So, this difference between the enhanced price and the earlier price is the buyers share and similarly, earlier the sellers were getting this much amount, now they are getting this amount.

This difference between the new price that they are getting which is this one and the earlier higher price that they were getting, before the tax, this is the sellers share. So, in short what is happening is that even when we have a tax only on the buyers, here as well the tax gets distributed between the buyers and the sellers and the market shrinks.

We can say that whenever there is a tax, the size of the tax together with the elasticity of the demand and supply curves will determine how much is the buyer's share and how much is the seller's share. So, the size of the tax is less, then both buyers and sellers will have to shell out a lesser amount of money.

If the size of the tax increases, they will have to give more money and whether the buyers have to pay more or the sellers have to pay more is determined by the elasticity of the demands in supply curves. But whatever happens, whenever there is a tax, it would lead to two things; one, it will get distributed between the buyers and the sellers and two, the market will shrink. And this shrinkage also leads to a shrinkage in the surplus.

We have observed before that whenever there is a tax, then the government gets a certain amount as the tax revenue. This tax revenue is determined by the size of the tax which is this much. This is the size of the tax, T and the quantity that is I mean traded in the market that is bought or stored which is Q .

Now, multiplication of Q which is the quantity demanded or supplied with the T or the tax size will give us the tax revenue. Earlier, we were having a situation in which we had a large con-

sumer surplus. It was given by this triangle and a large producer surplus, which was given by this triangle.

But in the new situation, what is happening is that now, we have a reduced amount of consumer surplus which is now given by this triangle. So, earlier, we had a larger consumer surplus, now we have a smaller consumer surplus. The producer surplus also reduces.

This is the new producer surplus that we have. So, it also reduces; a certain amount gets accrued to the government in the form of government revenue and we also have a deadweight loss because of this taxation, which is this gray color triangle. So, earlier, where we were having a large producer and consumer surplus, now the producer and consumer surplus have reduced. The government is getting a certain amount of the surplus in the form of tax revenue; but there is also a deadweight loss.

The government when it is taking money in the form of taxation, the government will have to make certain decisions. Now, we had observed before that economics is the science of making decisions. So, economics helps us answer things like what to produce, how to produce, how much to produce, for whom to produce, when to produce and things like that. Now, similarly, when we are talking about taxation and the government needs taxation for its own work ins.

And it also needs taxation money for conservation purposes and the government is doing conservation for the people. But then, when the government takes money from the people to do conservation for them only, then in this process the government also reduces the total surplus in the market.

The government gets a share of the surplus in the form of tax revenue; but it also creates a deadweight loss. Now, the question for the government is if we are taking these taxes from the people to work for them and in this process, we are also reducing their surplus, which is their welfare; then, how do we decide how much amount of money to take from the people? That becomes an important question. Because any maximization of the tax revenue can only happen by increasing the deadweight losses.

This now is an important question for the government; how do we increase the tax revenue, while keeping the deadweight losses at a low level and we saw that deadweight loss is the fall in the total surplus that results from the market distortions, such as taxation.

What is happening here is that if the government does impose a tax, then it distorts the market. We saw that the earlier quantity demanded or supplied in the market was large and after the imposition of the tax, the market shrinks. So, this is a distortion in the market.

Now, any such distortion in the market is going to reduce the total surplus that is there in the market and this reduction in the total surplus that results from a market distortion such as taxation is known as a deadweight loss. Now, taxes cause deadweight losses because buyers and sellers are prevented from realizing all the gains from the trade. Now, all the gains from the trade would mean this total surplus that was accruing to the buyers and the sellers earlier.

This was the total surplus that was being accrued earlier, but because of this deadweight loss, now there is a reduction in the surplus. Taxes cause this deadweight loss because buyers and sellers are prevented from realizing all the gains from trade and this loss of surplus does not even accrue to the government, since trades that become uneconomical due to the taxes do not occur at

all. So, now the question to the government is how do we maximize our taxes.

While ensuring that the deadweight losses are kept at the minimum. And in this context, we can talk about the Laffer's curve which tells us that when the size of the tax is small, that is T is small; with small T , Q will be large. Now, Q as you will remember is this much, this is Q . So, this much is Q . Now, if T reduces, then Q increases which means that the mode you increase the size of the T which is the tax size as it increases, the market shrinks even further.

The shrinkage of the market is related to the size of the tax. Now, when we have a very small tax that is T is very small, in that case Q is large; but then because T is very small, so Q into T in total is small. So, what that means, is that when T is small, then the total tax revenue which is given by this pink colored rectangle, it is small. Now, a situation of a very low amount of T is not good for the government because in this case, the government will not get a sufficient amount of money in the form of taxes.

Most of the countries do not have a very small value of T ; T is pretty substantial because when the T is very small, then the government would think that ok if I increase the amount of T by say a small value, then there will be a shrinkage in the market.

But probably that shrinkage will not be that large, which means that I should be able to increase the amount of my tax revenue without making a very big distortion because T today is very small and when the government has such a thinking, then the government would try to increase the value of T .

When the government increases the value of T , then it would lead to further shrinkage of the market. So, when the government increases the T to a medium level value, then we can observe that the tax revenue, here the tax revenue was very small, now the tax revenue has increased.

When the T increases even further, then probably you can have an even larger amount of tax collection. But then, this cannot go till infinity. Because for a very large value of T , Q will become so small because now the market has shrunk to only this much.

This is now the size of the market; whereas, earlier the size of the market was as large as this. The increase of I mean this larger market, now we have only this much of a market shrink and when the market has reduced to such a large extent, it means that Q is now very small.

Even with a large size T , we will see that Q into T again becomes very small. So, what we are getting from this is that a very small value of T will not provide sufficient money to the government; a very large value of T will also not provide a sufficient amount to the government.

The government should go for a value of T that is in between and this brings us to the Laffer's curve. Now, Laffer's curve is a plot of tax size on the x axis versus tax revenue on the y axis. So, Laffer's curve tells us that as the size of the tax increases, the revenue collected reaches a peak and then starts to decrease and for a very large tax size, we will have a very minuscule amount of tax revenue. So, when we say that economics is the science of decision making.

This Laffer's curve is one indication of up to the government about how to design the tax system. So, a very important consideration that we are getting from Laffer's curve is that the government should have a value of T that is neither very small nor very large, if it has to have a sufficient amount of tax petty.

But the government cannot just work on tax maximization. Now, this is because of the dead-

weight losses and what we had observed was that in the case of a very small T , the deadweight loss is very small. So, this gray colored triangle, this is the deadweight loss. Now, when T is very small which means this height is very small.

Then we have a very small triangle. But when T increases, the deadweight losses increases. When T increases further, the deadweight loss increases even further and it goes on. So, in this case, we are not observing any maximization of the deadweight loss or any point of minimization; but it is just that as the tax increases, the deadweight losses also increase. But this is an important question for the government. Because earlier when the government was looking at the Laffer's curve.

Then probably this much was the optimum size of the tax. But if we look at this curve at this optimum, the deadweight losses are already too high. So, in this case, with the optimum that is given by the Laffer's curve, the deadweight losses are already too high. So, now, the government will have to think again. The government will say that 'ok, I need this tax revenue to work for the people, but in the process of maximizing the tax revenue, I have already hurted people.'

Because I have already reduced their surplus by a very large amount as is given by the dead-weight losses. So, this is another consideration that the government should keep in mind, while designing the tax system, that we cannot have a tax system that works only on the maximization of tax revenue.

We will also have to look at what is the amount of acceptable deadweight losses. Now, this term acceptable dead weight losses, it would depend on the country, it would depend on the culture in that country, it would also depend on the level of development in that country and also, on special considerations such as wars. Now, in the time of a war, the government may increase this amount of T probably towards the maximization of the Laffer's curve.

The government will try to maximize the tax revenue to use for war purposes. Because in that case even when the deadweight losses are large, people probably will not mind. But in a normal circumstance, if the government tries to go for a tax maximization. So, people might just revolt against the government. So, this is an important consideration to keep in mind, while designing the tax system. But then, this again is not the only consideration.

We have seen that the taxes reduce the total surplus, introduce deadweight losses and the quantum of the deadweight losses depends on the elasticity of demand and supply. So, essentially if we have a very elastic demand and supply, then in that case the deadweight losses will be even greater and the deadweight losses increase with the tax, but government revenues increase and then decrease as in the case of the Laffer's curve. So, the government has now 2 variables to work on: one is the size of T so that it can maximize the tax revenue, while keeping deadweight losses to an acceptable value; but then, once the government has decided that ok this should be the size of T , the next question is when should the government charge it from and also, if there are any other implications.

Implications such as the administrative burden on people. Taxes increase the administrative burden for people, who are filing their returns. Because in the case of a tax system what the government does is that the government decides that people have to pay this much amount of tax, this is the tax size. But then in a number of cases the government asked the people to do this computa-

tion by themselves. So, a very similar situation to what we have in our country.

At the end of the financial year, what we do is that we make a return of the amount of earnings that we had in the financial year and we compute the amount of taxes that should be given to the government. And that amount of tax should be given to the government. Now, the thing is for a very large majority of people, finding their returns, doing these computations can become a burdensome activity. Because it requires time, time that could in effect have been used for certain other productive purposes.

When the government insists on having a tax even if the size of T is very small, then it would entail people to spend their time in filling out their returns and this time is an unproductive time for a large majority of people. So, one consideration is that taxes increase the administrative burden for people.

One alternative when the government is designing the tax system is a return-free-filing. Now, what is a return-free-filing? In certain countries what happens is that when you do any transaction, so when the one when your employer is paying you a salary, this salary is given in the form of an electronic payment and when the employee is making this transaction, a copy of this transaction gets to the government and the taxes gets deducted at the source.

When you make any payments, say for the education of children or say committing a medical need for which there is an exemption in the tax code, whenever any such payment is made, then that payment is also made electronically and the information automatically gets to the government.

At the end of the year, what happens is that the government just sends a piece of paper probably electronically which gives a record of what sort of money you received and what sorts of payments you made and if those payments get into any of the exemptions, they are automatically exempt from the taxes. There is a computation of the taxes done, a deduction of all different kinds of taxes and then, you get the final value.

You only have to check this document once to ensure that there is nothing that is unacceptable. So, probably there is no deduction that should have been made, but the government failed to make it. But essentially the administration gradually gets reduced to quite an extent.

Because the government has given you all the records that it has about your earnings and about your expenses. The government has done all the calculations and you just have to pay that amount of tax; probably that too electronically. Now, in that case, we call it a return-free-file. So, people do not have to file a return at the end of the year. In most cases, people just pay the amount that is shown on their statement and that amount gets paid and that is the end of the story.

Very similar to what we do in the case of credit cards. So, at the end of the month, the bank sends a statement about what sorts of spending it has observed on the card and how much interest needs to be paid. If everything is fine, you just pay that amount. What if the bank asks you to keep a note of all the transactions that you are doing and then, pay them an interest on that transaction. That would have become an extremely difficult task for most people and similar is the case of taxes.

So, filing of the taxes creates an administrative burden which increases the inefficiency in the so-

ciety because that time, that effort could have been used for certain productive purposes. So, when the government is designing a tax system, one option that is there with the government is return-free-filing that would increase the efficiency of the whole process. Another consideration is complications in the tax code. Now, what is that? The government when it is collecting taxes, it makes a tax code.

The tax code would provide a list of different things that the government is promoting or say not promoting. So, it is possible that the government says that if you provide a donation to a charitable institution, you will get an exemption from the tax. Now, why would the government do that? Because the government wants to promote donations to these charitable organizations. Now, this is a way we have seen in the case of the principles of economics that incentives can make people do certain things.

And so, a deduction from the taxes can be used and is used by the government as an incentive to promote certain activities.. Now, what happens is that over time, the government goes on making additions and subtractions to the tax code and with time, it becomes extremely complicated.

So, you do not know which all activities are going to get an exemption, which all activities will not get an exemption in the current revision of the tax code. So, probably something for which you were getting a deduction last year has been removed from this year's tax code or probably, something that you were not making a deduction on last year has been added. Now, whenever we have such a situation, when people are filing their tax returns, then they have to go through the current provisions that are there in the tax code. It again increases administrative burden; it again increases gratuity; it again increases inefficiency. Because this time that everybody is spending on reading the tax code and finding out how they can save on their taxes could have been spent on say much productive uses. So, this is another consideration, how complex or complicated or simple should the tax code be.

Now, if the government goes for a simplification of the tax code, so in that case, we will have a situation in which the administrative burden will be reduced. People will know very easily that ok, these are say 4 or 5 activities that we can get exemption on and nothing more, nothing less.

But in that case, the government will not have that fine a control over the kinds of activities that it wants to incentivize or disincentivize. Because after all these provisions were only made so that the government could incentivize or disincentivize certain activities. So, if the government goes for a finer control, it would increase complexity;

If the government reduces its control, it would make the tax code simpler. But in that case, it might reduce the spending on those activities that the government was finding necessary for society. Now, what it means is that the government was putting these complications because of the economic principle that governments can sometimes improve upon the market outcomes. So, this is one way of improving the market outcome.

But if the government goes for a simplification, then probably the government will be shifting from its duty to improve the market outcomes in the best possible manner. It will be giving out its power. That is another consideration while designing the taxes. Another is that exceptions in the tax law may permit very low taxes.

What happens in a number of cases is that there are people, who are experts in finding out the ex-

ceptions, finding out the loopholes and in the case of certain people, they may do their spendings or they may do an asset allocation in such a manner that overall, they have to pay a very less tax. While everybody on an average is paying say 20 percent tax, there could be certain people who are paying only 3 or 4 percent of their income as taxes because they are making use of all the loopholes that are there. Now, these loopholes were again put into the tax code because the government was trying to promote certain activities.

But then, if this promotion of certain activities through this incentive of a tax break is extended to such an to such a level that it becomes a loophole, then that would again become counterproductive. So, here again the government has to look at how much is the amount of control, how much is the amount of exceptions that it wants to put in.

Now, exceptions are helpful to a large number of people for 2 things; one it reduces the amount of tax burden that they have to pay and two, by using these exceptions, the government channels their money into those activities that can help the society. Now, if these exceptions are removed, then probably these benefits will also be triggered.

So, this is another consideration. Another consideration is whether to choose for efficiency or for equity. Lump-sum taxes are the most efficient, while progressive taxes are the most equitable. Now, what is a lump-sum tax? A lump-sum tax is a tax that is the same amount for every person, which means that if the government says that from this year onwards, every person will have to pay 1000 rupees as tax. So, that is a lump sum tax.

It has got nothing to do with whether you are rich or whether you are poor or whether you are a soldier or whether you are businessman, it has got nothing to do with anything; whether you are an old person, whether you are a young person, nothing good. It is a lump-sum tax. If you are a citizen of this country, then every year, you will pay 1000 rupees as tax. Now, a lump-sum tax in certain cases is very efficient because everybody knows from the beginning of the year that ok, I will have to pay 1000 rupees as tax.

The rest of the money that they have that can be put into a use that will provide them the largest amount of returns. It simplifies everything; it simplifies the administrative burden and regally because everybody knows that they just have to pay 1000 rupees and the rest of the money will probably be used for such productive purposes as good help the society as well because it would be increasing the surplus in the society. But then, if we go for a lump-sum tax.

Then there will be certain people who would say that ok in this tax code, a poor person is being forced to pay the same amount as is a rich person or probably, somebody would say that a person who is very old, he or she also has to pay the tax at the same rate as a young person is paying; whereas, the old people have a large amount of medical requirements, they cannot work that hard. So, this is a tax that is discriminatory.

It is putting a negative burden on the old people; it is putting a negative burden on the poor people. So, now, this again becomes a consideration. The lump-sum tax was good because it was reducing the treasury of everybody; but then, in the process of reducing the treasury of everybody, it might increase the amount of tax that needs to be paid by a certain specific set of people, who probably need more help from the government. So, that is because they are in a lesser position to pay the taxes. So, this is a lump-sum tax.

So, a lump-sum tax is the most efficient. Another kind of tax is a progressive tax. Progressive tax is a tax for which higher income taxpayers pay a larger fraction of their income than do low-income taxpayers. In our country, we have a progressive tax system. The more you earn, the more you pay. This is the progressive tax system.

It ensures that poor people who have less earnings will also have to pay less taxes; old people who are not working because of their old age or because of certain health conditions or because they have retired. So, those people also will have to pay less taxes. That is a progressive tax.

Now, a progressive tax is very equitable because it shares the burden in such a manner that people do not feel a very large amount of pinch. In the lump-sum tax, the poor people or the old people would be feeling a very great amount of pinch because they have to pay the tax at the same rate as the other people are paying.

But in the case of a progressive tax, it is much more equitable. So, this is another consideration that the government has to keep in mind; whether it wants to go for a lump-sum tax or a progressive tax because here again, we have pros and cons of each of them.

Another consideration is regarding who should pay and here, we have got two principles. The first one is called the benefits principle. The idea that people should pay taxes based on the benefits they receive from government services. What we are saying in the case of benefits principle is that the benefits principle says that the taxes that you pay is just a form of spending that you do for getting certain services. So, the government provides services such as protection.

Now, a person who is rich, probably has a large amount of assets. So, this person would require a greater amount of police protection than say a person who does not have a very large amount of assets. Because if there is a theft, then probably a thief would want to perform theft in the house of a rich person.

So, because of the presence of the police, the rich person is benefited more than the poor person. Now, if the rich person is getting more of the services in the form of the police services, protection services; then, the rich person should also pay a greater amount of share in the form of taxes. So, this is what the benefits principle says. The idea that people should pay taxes based on the benefits that they receive from the government services.

Rich need more police protection, so they should pay more for the police protection. Roads should be built and maintained by taxes on petrol and diesel because the people who are using the vehicles, the people who are using petrol and diesel, they are the people who are going to be using the roads.

So, they should be paying for the building and for the maintenance for the upkeep of the roads. Now, this is the benefits principle and it changes the work of the government to that of a private provider of services. So, probably, if we shifted to a benefits principle, then there could be say a private person who provides protection services. So, this person employs a number of security guards and he or she provides protection services - security services to rich households.

Now, in that case, the benefits principle would say that ok now these rich people do not need police protection because they have had a private security service. In this case, now they should be repaying less for the less in the form of taxes. Similarly, when we talk about the roads and their building and upkeep being done by taxes on petrol and diesel, then probably there could be a pri-

vate contractor who builds his own roads.

And in that case, he is going to charge the people for these roads. Now people should have the option whether to pay the government or whether to pay the private contractor. Now, this is what the benefits principle would say. But what about those services that everybody is using, things such as clean air, clean water that are all the benefits of conservation. If you get a thrill of seeing a tiger, then that thrill is something that you will only get when the tigers are there.

Now, probably you can say that no I want to save my money and so, I am not going to go see a tiger. So, why should I pay for the conservation of tigers? But then, if everybody starts to think like that, then probably in a short period of time without any protection; all the tigers get post upon and once that happens, it is possible that your next generation or their next generation that is your children and grandchildren, they want to see a tiger; but then there is no longer any tiger left.

So, the benefits principle, it may help in certain cases, but in a large number of cases and especially for questions of conservation benefits principle might not apply. Because how are you going to charge everybody for safe clean air; how do you figure out who is using how much of the clean air and how much of dirty air or who is using how much benefit of biodiversity and who is using less amount of biodiversity. So, these are questions that are extremely complicated to answer.

So, the benefits principle might be used in certain cases in a tax system; but for a large number of cases, it just does not apply. Another principle is the ability to pay principle, it is the idea that taxes should be labeled on a person according to how well that person can shoulder the burden.

That is, does the person have the ability to pay and the greater is the ability of a person to pay, the more should be the tax. Which means that there should be an equitable taxation system. An equitable tax system can be described in terms of the vertical equity and the horizontal equity. Vertical equity is "the idea that taxpayers with a greater ability to pay taxes should pay the larger amounts", which can take the form of proportional tax, regressive tax or progressive tax.

In the case of vertical equity, we are saying that people who have a larger ability to pay taxes should be paying the more taxes and people with a lesser ability to pay taxes should be paying lesser amounts of taxes. Now, this can take the form of a proportional tax. Proportional tax is a tax for which high income and low income taxpayers pay the same fraction of income, which means that if we have a tax system that is a proportional tax system, then in the tax code.

We will say that ok everybody has to pay a 5 percent tax or say a 10 percent tax. Now, in the case of a 10 percent tax, a rich person will also be paying 10 percent of his or her income in the form of taxes and a poor person will also be paying only 10 percent of his or her income in the form of taxes.

In this case, the taxation is proportional. Because everybody has to pay the same proportion of their income in the form of taxes; but then, it is an equitable system because the rich person who is earning more will also be paying more because that 10 percent is now a very large amount.

What we are saying here is that a person who is earning say rupees 10 crores will be paying 10 percent which is equal to rupees 1 crore and a person who is earning rupees 10 thousand, here again this person will only be paying 10 percent. And in this case, the 10 percent is rupees 1000.

This is an equitable tax because we are asking both the rich and the poor to pay only 10 percent. But by asking them to pay 10 percent, we are taking a larger sum from those people with a greater ability to pay and we are taking a smaller amount from those people who have a lesser ability to pay.

So, even though, in this case the taxation is proportional to the income, it is having a vertical equity because we are taking a larger amount from people with a greater ability to pay and a smaller amount from people with a lesser ability to pay. So, this is a proportional tax. Another tax is a regressive tax, a tax for which high-income taxpayers pay a smaller fraction of their income than do low-income taxpayers because when the income is more, there is in total more tax even when the fraction is small.

In the case of a regressive tax, what we are saying is that the poor people will have to pay 10 percent, but the rich person will have to pay only 1 percent. Now, in the case of the rich person, this 1 percent is 10 lakhs of rupees; rupees 10 lakhs. Now, this regressive system would say that this is still an equitable system because the person with a greater ability to pay, a person who is earning 10 crores of rupees is still paying a very large amount.

He is paying 10 lakhs of rupees and a person with a lesser ability to pay, who is earning 10 thousand rupees is paying 1000 rupees. Here again, we are taking a larger amount from those people with a greater ability to pay and a smaller amount from those people with a lesser ability to pay. People would say that yes, this again is an equitable system because you are taking a larger amount from people who have a larger capacity to pay.

But then, this is a regressive tax system because the richer a person is, the smaller fraction of his or her income needs to be paid as taxes. So, which is why we say that this is a regressive; the higher you go in the income ladder, the lesser proportion of your income you have to pay as taxes. But here again, it is an equitable tax. And the third tax is known as progressive tax, a tax for which higher-income taxpayers pay a larger fraction of their income than do lower-income taxpayers.

What we are saying here is that in the case of these people, who are earning 10 crores; now in the case of a progressive tax, we are saying that the higher one goes in the income ladder, the more is the taxation. Which means that the poor person will have to pay 1 percent and the richer person will have to pay 10 percent. So, 10 percent of 10 crores is 1 crore and 1 percent of 10 thousand is 100 rupees. Now, in this case this again is an equitable tax.

It has vertical liquidity because a person with a lesser capacity to pay is paying a lesser amount and a person with a greater ability to pay is paying a larger amount. So, here again, it is equitable; but it is progressive because the more you earn, the larger fraction of your income. That is if you are earning less, you are paying 1 percent; if you are earning more, you are earning a larger amount, a larger fraction 10 percent. So, the more you earn, the greater fraction of your income needs to be paid as taxes.

Now, we can have all these different kinds of vertical equities, these different forms of taxation; proportional, regressive or progressive that can lead to vertical equity. But again, which of these is going to be used in a society will depend on that particular society.

Because in the case of a progressive tax, there are certain people who would say that - 'yes pro-

gressive tax is good; it is great because the poor people have to pay a lesser fraction of their income, the rich people have to pay a larger share of their income'.

But somebody else would say that - 'ok, so if I work harder, if I earn more, I will have to pay a larger portion of my income to the government which means that I will be left with an even smaller fraction. So, is the government not disincentivizing people to work'. Because again, people respond to incentives and if you tax the rich people with a greater fraction of their income, are you not disincentivizing them to be rich? So, do you want to convert the country into a bunch of poor people?

No, these are questions that are not just economics questions, these are philosophical questions. So, this is vertical equity. Another equity is horizontal equity. The idea that taxpayers with similar abilities to pay taxes should pay the same amount. Now, in the case of vertical equity, we were saying greater ability to pay taxes and in this case, in the case of horizontal equity, we are saying people with similar abilities to pay taxes should pay the same amount.

When we talk about verticals, we are talking about differences. So, when we say vertical, we are saying that this person needs to pay a different amount from this person. In the case of horizontal equity, we are saying that if 2 people are at the same level, then they should be paying the same amount of money as taxes.

And in this case, we are saying similar ability to pay; but then, the question is what is a similar ability to pay. If there are 2 families and each family is earning 10 lakhs of rupees and one has 2 children, the second has 10 children. Now, should they pay the same tax? Because in the case of a family with just 2 children, they probably have to spend less on having just 2 children. The expenses on food, the expenses on education, the expenses on clothing will be lesser because there are only 2 children.

On the other hand, the second family that is having 10 children will have to spend more on education, more on food, more on clothing, more on everything. So, these are 2 families that are each earning 10 lakhs of rupees; but do they have the same ability to pay or should we say that the family that has 2 children has a greater ability to pay because their expenses are less and the family with 10 children has a lesser ability to pay because they have more children and so more expenses.

But if we make that distinction and if we say that the family with 10 children will have to pay less taxes, are we not incentivizing families to have more children, when we are already suffering from overpopulation. So, that is the question: should they pay the same tax?

And if we allow tax breaks to the second family, are we promoting large family norms? So, this is another consideration that the government needs to keep in mind. Another consideration is should we aim at average taxes or marginal taxes. Now, average tax is total taxes paid divided by the total income.

Which means that if you are earning 100 rupees and you are paying 10 rupees; then, your average tax is 10 percent. Marginal taxes on the other hand is the amount by which taxes increase from an additional unit of income, which means that the marginal tax is asking the question that if I am earning 100 rupees, I am paying 10 rupees; if I earn the next 100, will I have to pay 10 rupees on the next 100 or do I have to pay 20 rupees for earning the next 100?

That is the amount of tax that I need to pay for the additional income that I am making. So, if I earn 101 rupees, how much amount of tax do I need to pay on this 1 rupee? Now, if we say that people who are earning less will have to pay less and the more they are earning, the higher will be the tax bracket; that is if the marginal taxes are high, then are we seeing as a society that people should not work hard, they should not earn more.

This again is a consideration. Should the government aim for average taxes or marginal taxes in the tax scheme? Similarly, should we have a tax on income or a tax on consumption? A tax on income discourages people from saving; whereas, a tax on consumption promotes people to save. Why? Because if there is a tax on consumption, it would mean that the more you spend, the more you will have to pay. So, whatever you are earning, you can keep with yourself; but the more you will spend, the more you will have to pay the tax, which means that the government is saying that everybody should try to save as much as possible. Because the more you save, the less you will have to spend. On the other hand, in the case of an income tax, the more you earn, the more you have to pay the taxes.

So, a tax on spending will promote people to have the habit of saving. So, that will increase the amount of savings that we will have as a nation in total; but here again, the question is can we shift from an income tax to the consumption tax because it may be complicated or should we just say that because for so many years, we have been having income tax. So, let us just stay with the income tax. So, these are all different kinds of questions.

And a large number of these questions are not just questions of economics, but also philosophical questions. Because you need to make a choice between efficiency and equity. And as we saw before, economics is the science of decision making; economics is the science of choosing between options.

You cannot have all of everything, you will have to choose between a lot of things; you can choose between efficiency or you can choose to have more equity. This is a choice that needs to be made and which makes the design of the tax system at times complicated.

That is all for today. Thank you for your attention. Jai Hind!

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Module 9
Industrial organisation and Conservation
Lecture 1
The costs of production

Namaste! Today we begin a new module which is Industrial Organisation and Conservation. This module will have 3 lectures: The Cost of Production, competition and monopoly. So, let us begin with the cost of production. Now, in economics we say that people do rational decision making which means that people take into account all sorts of information that they can have access to and process that information to maximize their benefits, that brings us to the topic of cost benefit analysis.

Rational decision making is based on cost benefit analysis which means a study that compares the cost and benefit of providing a good or service. So, essentially what it says is that, everybody tries to maximize the benefits that they have while reducing the cost as far as possible. If you have maximum benefits at the lowest cost, then that is the most relational decision that can be taken.

This is the cost benefit analysis, a study that compares the cost and benefits of providing a good or a service, but herein lies a problem. When we say that the benefits need to be maximized and the costs need to be reduced as far as possible in a number of cases this reduction in cost may also have severe environmental considerations.

And we have observed a number of environmental disasters that have occurred because of cost cutting. Common example is the Bhopal gas tragedy. We shall explore the Bhopal gas tragedy in more detail in a later module but in short what was happening was that the union carbide plant was working at only 20 percent of its capacity because the insecticide that it was manufactured called 7 it was not selling at that fast phase.

And so, the plant management decided to go for fast cutting because they were having a huge stockpile of insecticide that they were accumulating. Now, this cost cutting involved things such as making of the gas methyl isocyanate, it was stored in a liquid form, but this compound was made in large quantities.

It was stored which was against the norms of the company. Then it was stored in tanks that had to be around 50 percent full of mech and the rest of the space had to be kept empty, but they were filled above the capacity. The refrigeration system was shut down to cut cost and the plant was very yield maintained because of which water entered inside the tank and it started a run-away exothermic reaction.

In a normal plant there were a number of measures that could have stopped this gas from coming out. So, if there was any gas leak then it would have led to the sounding of alarms, but then the plant in Bhopal it was not computerized did not have those sensors. Then if the gas still leaked away, then there were options of neutralizing the gas using chemicals, but then those towers were not working.

If the gas was able to pass those chemicals, then any amount that remained should have got burned in a flare tower. In a flare tower there is a flame that is kept on so that any gas that passes through it gets burned, but then this flare tower itself was not working again because of a cost cutting measure.

Because of several cost cutting measures the locals were untrained, they did not have the equipment, they did not have the resources to tackle any gas leakage. So, because of a huge number of cost cuttings the disaster occurred. The gas leaked in 1984. So, this is one environmental disaster that can be linked to cost cutting and the tragedy still continues.

There are a number of disabled people in Bhopal because of this and this was heavily documented. Another environmental disaster due to cost cutting is the love canal tragedy. In this case there was a firm that took the chemicals that were untreated industrial waste and they just dumped them into the love canal.

So, this canal was converted into a dump site and later on this site was handed over to the civil authorities for the construction of a school and so, a school was constructed on top of a dump site that was having a very huge quantity of untreated industrial effluents and a lot number of children got exposed to those chemicals. Now here again the company was only interested in doing the cost cutting, but even 35 years later it is still losing poison.

Another example is the Minamata disease. In which case the Chisso Corporation in Japan dumped the untreated methyl containing catalyst into the oceans into the seas. The fishes started to die off, the animals started to show neurological symptoms and in a short while people also started to show a large number of neurological symptoms and disabilities.

Here again the company could have installed equipment to treat the waste, but it was not done for cost cutting. Cost cutting leads to a very significant influence on the environment sacrificing health to corporate profits. Itai Itai victims settling with the mining operation release of large quantities of dioxin from this plant in severe soil or in recent past cost cutting leading to the Gulf of Mexico oil spill.

BP's cost cutting was blamed for the avoidable deep water horizon oil spill. So, in all these cases what we are observing is that cutting of cost by firms can lead to a large number of environmental disasters. But then the firms are doing this cost cutting because they seem to be racial decisions for these firms.

Because in economics we assume that everybody is a rational decision maker and in a number of cases this cost cutting does appear to be rational. This is rationality in the short term: in the long term it can have very tremendous consequences, but then in the short term people do think that these are rational decisions.

Now, because cost cutting has such huge impacts on conservation, it is prudent that we should understand what is cost, what is the cost of production and why do companies go for a cost cut-

ting. So, the firms go for a cost cutting because the firm's cost determines the profit and in this context we can define the total revenue, total cost and the profit. Total revenue is the amount a firm receives for the sale of its output - when a firm is selling something the amount that it receives for the sale of this output. When it is selling something, the total amount that it receives is the total revenue and total cost is the market value of the inputs a firm uses in production. So, to take an example let us say that there is a firm that is manufacturing some of us.

Now suppose in a day the firm sells samosas worth rupees 1,000. Now this sale has broadened a revenue to the firm which is rupees 1,000. So, they have sold samosas that have worth 1,000 rupees, but then this 1,000 rupees is not the profit of the firm because there are several costs involved.

You have the cost of the raw materials, you have the cost of electricity, you may have the cost of the workers, wages, you may have a rental cost because there is a space that has been rented to make these samosas. You can have n number of costs and suppose all these costs add up to rupees 750. So, in this case we will say that this is the cost of production and the difference between the revenue of 1,000 rupees and the cost of rupees 750 will give us the profit.

The profit is 1,000 minus 750 is rupees 250 for this particular day. So, total revenue is the amount a firm receives for the sale of its output, in this case 1000 rupees total cost is the market value of the inputs a firm uses in production. Now we are emphasizing market value because we will not say in the case of raw materials, we will just say that the raw materials is 150. We will not say in this case that the raw material is maida or it is water or it is salt, but what we are doing is that we are taking the market value of all of these and we are saying that raw material is in total 150 rupees. So, the total cost is the market value of the inputs a firm uses in production and profit is total revenue minus total cost.

Now, when we talk about the cost there are explicit costs and implicit costs. Explicit costs are input costs that require an outlay of money by the firm. The important thing here is the outlay of money such as wages to workers cost to cost of raw materials. So, in the case of explicit costs we are asking the question what are the inputs for which the firm is paying money.

The firm is paying money to buy maida, the firm is paying money to buy potatoes, the firm is paying money to get salt, the firm is paying money to workers, the firm is paying money for say electricity, fuel, rent and so on. Now, all those things for which the firm requires an outlay of money are known as explicit costs. Implicit costs are input costs that do not require an outlay of money by the firm.

So, these still are costs, but they do not require an outlay of money. Example the opportunity cost of foregone income from other sources, the opportunity cost of capital that could otherwise have earned interest. An example of this opportunity cost is say there is a person who was working in a software industry and was earning say 60,000 rupees in a month.

Now, this person leaves his job and starts a startup company to say uh manufacture spectacles. Now when the person is making spectacles in this startup, he is not earning the 60,000 rupees that he was earning in the software firm in his earlier job. Now this 60,000 rupees is something that this person has given up to start the startup.

This 60,000 rupees is an opportunity cost that has been given up and so, we will count this as an

implicit cost in making of the spectacles. So, this is an input cost that does not require an outlay of money by the firm. So, the spectacles firm will not say that we have forgone this 60,000, but then this is a cost for this person. Another example is the opportunity cost of capital that could otherwise have earned interest.

Suppose this person, to make his spectacles factory, spends say 20 lakhs of rupees to get the space and to get certain equipment. Now this 20 lakhs of rupees had he not invested it in making of uh this startup firm could have been say put into a bank and in that bank this money would have earned certain interest.

When this money is being used for the startup firm, then the person is losing out on that interest that this capital would have earned otherwise. So, this again is an implicit cost. So, this is a cost that this person is paying, but this is not a cost for which the firm will put up an outlay of money. So, this is an implicit cost.

Depending on whether we include the expense, the implicit cost or not in the computation we have two different kinds of profit. Now economic profit is defined as total revenue minus total cost including both the explicit cost and the implicit cost.

Which means that, if the person who is starting this startup, suppose in the first month the earnings or the revenue is rupees 1 lakh and the cost of inputs that is the cost of the raw materials, electricity, payment of wages and so on is rupees 30,000. So, this is the explicit cost. Now, let us look at the implicit cost. This includes the 60,000 rupees that he otherwise would have earned in the software firm plus say 20,000 rupees that he would have earned as an interest.

In this case we will say that the implicit cost in total is 80,000 rupees. Now when we talk about the economic profit, we are saying total revenue minus total cost which is in this case the total revenue is 1 lakhs of rupees, total cost is 30,000 plus 80,000. So, in this case the total cost is rupees 1.1 lakh.

Now, this is the total cost and this is the total revenue 1 lakh. In this case we will say that the economic profit is rupees 1 lakh minus rupees 1.1 lakh is minus 0.1 lakh rupees. In this case what we have computed is that, the economic profit is minus 0.1 lakh which means that this person is at an economic loss because the profit is negative whereas, the accounting profit is total revenue minus total explicit cost.

Total revenue is 1 lakh of rupees. This is the total revenue total explicit cost is 30,000 rupees and so, we will say that the accounting profit is 1 lakh minus 30,000 rupees is 70,000 rupees. So, this person is earning an accounting profit of 70,000 rupees, but an economic profit of minus 10,000 rupees. So, there is a big difference between the profit or loss that a person would feel when there is a computation being done on an accounting basis or on the economic basis.

In this case the accountant might say that ok this person every month is earning 70,000 of rupees. So, this person should continue to be in this startup, but the economist would say that no this person is actually suffering a loss of 10,000 rupees every month because had he not set up this startup, probably he would have been working in the old company earning 60,000 rupees from there and getting 20,000 rupees out of the interest income from the money that he kept in the bank which now he has spent in making of the startup.

And so, in that case he would have earned more in the previous position as he is earning in the

current position. And so, there is a big difference between economic profit and accounting profit. That is when we are taking an economic versus accounting view, if we talk about the total revenue. So, in both the cases total revenue remains the same, explicit cost remains the same, but when we take an economic view of a firm, we also deduct the implicit cost from the total revenue to get an economic profit.

Whereas, in the case of an accounting firm they do not incorporate the implicit cost and so, the accounting profit in a number of cases is much greater than the economic profit. Now this distinction between economic view and accounting view has a very big bearing for conservation because say a company or a firm that is manufacturing goods and is polluting the environment. Now how would this uh the accountant and the economist view such a firm?

Now let us say that the net revenues of this firm are rupees 10 lakhs and the explicit cost is say rupees 3 lakh, but then when the firm say does not install a device to control the pollution, it also harms the environment because of pollution and the harm to the environment is say rupees 5 lakhs. Now the economist would say that this harm to the environment is leading to an implicit cost because if the environment was not harmed, then probably this 5 lakhs would have been accrued to the society.

This is an implicit cost. Now this harm to the environment could probably have been removed by installing a pollution controlling device, which would have caused the company 1 lakh of rupees. Now let us look at the view of this firm from an accounting point of view. From an accounting point of view the accountant would say that the net revenues are 10 lakhs, the explicit cost is 10 lakhs, but if we install this device then the explicit cost would be 3 lakhs plus 1 lakh is 4 lakhs.

The explicit cost increases when the pollution controlling device is installed and currently the profit is 10 minus 3 lakhs is 7 lakhs, but if this device gets installed then because there is an extra explicit cost then the profit will come down to 6 lakhs and in this case the accountant would say that oh this company should not install this device whereas, the economist would say that currently the total cost which is the explicit cost plus the implicit cost is 8 lakhs.

If the device gets an explicit cost, we will forego this implicit cost. So, when once the device gets installed then the total cost would be 3 lakhs of the explicit cost today plus 1 lakh is 4 lakhs, but we will be saving on this 5 lakhs and so, the profit would be 10 lakh minus 4 lakh is 6 lakhs, but currently the without the the device the total cost is 8 lakhs of rupees and so, the net profit is 10 minus 8 is 2 lakhs.

Currently the profit is 2 lakhs with the device it will increase to 6 lakhs. So, the economist would say that the firm should install this pollution controlling device. Now in both of these cases we are doing rational decision making, we are doing a cost benefit analysis, but when we incorporate all the explicit and all the implicit costs then we have a much better picture of what the firm is doing to the society and in that case our decisions will be much better.

When we look at things from the accountant point of view, we do not incorporate the implicit costs and in such a scenario in a number of cases it is possible that we will take a decision that will not be in the best interest to ourselves or to our society. Now, similar to the example of the person who left his software job and started a startup, in that case the accountant will say that this person is earning a profit and so, he should continue in this startup whereas, the economist

might say that no he was in a much better position earlier.

Similarly, in this case the accountant will say that this device should never be installed because it will bring down the accounting profit because it will increase the explicit cost by 1 lakhs of rupees. But the economist would say that by increasing the explicit cost by 1 lakh we are saving 5 lakhs in the implicit cost. So, there is a net saving of 4 lakhs of rupees which is much better. So, this is why we need to understand the difference between the economic view and the accounting view.

Now, when we are doing this cost benefit analysis another thing that we need to keep in mind is the marginal product. Marginal product is the increase in output that arises from an additional unit of input. So, now, what we are trying to do is, we are asking how much of things should be produced. So, there is a cost of production we have implicit cost we have explicit cost there is a profit.

Now, the thing is, should we make more and more of this stuff or is there a limit to which we should be making this stuff? How do we decide that? So, for that we are now getting into how much to produce. So, in this context we can talk about a marginal product which is the increase in output that arises from an additional unit of input.

A good example is this firm that is making samosas. Now if the number of workers is 0 in that case the total output is 0 because there is nothing that is being made, but in this case there will be certain fixed cost because even when you are not producing this the samosas even then you have installed the machines you are paying the rent for the land and so, there are certain fixed costs. So, the fixed cost remains the same whether you make the product or not.

Now, if the firm employs 1 worker and the output of samosas now becomes 50. Now the marginal product would ask the question: how much is the increase in the output because of one additional unit of input? In this case the input is the labour. So, the marginal product of labour in this case is 50 minus 0 is 50.

If the firm employs two workers and the samosa output increases from 50 to 90, then the marginal product will be the increase in the output that is 90 minus 50 because of an additional unit of input. The marginal product in this case becomes 90 minus 50 is 40 and so on. With each additional input of a worker there is a change in the output marginal product is asking the question how much is this change.

So, the marginal product is the increase in output that arises from an additional unit of input. Now this input can be anything, this input can be in terms of the workers that are employed, this input can be in the terms of raw materials, it can be in terms of the number of machines that are installed in the factory and so on.

But for any input when we increase the input by 1 unit what is the net increase in the output is what marginal product is asking. And in the case of marginal product we normally observe a diminishing marginal product which is the property whereby the marginal product of an input declines as the quantity of input increases. What we are saying here is that when the number of workers is increasing from 0 to 6, the marginal product is reduced in each case.

That is when you increase the number of workers from 0 to 1, you get a much greater increase in the marginal product than when you increase it from 5 to 6. So, in this case from 0 to 1 you are

getting a marginal product of 50 whereas, when you increase it from 5 to 6 you are getting a marginal product of only 5. So, this is the law of diminishing marginal product.

The property whereby the marginal product of an input declines as the quantity of the input increases. That is when we plot the number of workers on the x axis and the marginal product on the y axis, the marginal product with increasing number of workers goes down and there are several reasons for this. One is that there can be crowding in the factory.

Earlier each worker was getting sufficient space to work, but now because of the overcrowding people are not getting sufficient space to work, sufficient space to move. That would reduce the efficiency of every worker because earlier the worker could move from point a to point b say in 30 seconds, but now because there are 5 people standing between point a and point b and this worker has to negotiate the path.

In place of 30 seconds now he is taking say 2 minutes and so, the output per unit time will go down. Another reason could be insufficient access to equipment. So, probably there is only a single mixer in this factory and so, when there was only 1 worker, this worker was having 100 percent access to the equipment.

But now what is happening is that when this worker - when you have 6 workers and when 1 worker is going to that equipment he finds out that there are two people already in the queue. So, now, he does not have sufficient access to the equipment. At the same time another reason could be things like chit chats.

With more people there is more chit chatting and so, the people are not putting up that much amount of output as they were doing without the chit chats. So, there is a certain amount of social loafing. But the thing to remember is that we have a law of diminishing marginal product. As you increase the amount of input the marginal output of or the marginal product of the input would go down.

Another concept here is the production function which is the relationship between the quantity of inputs used to make the good and the quantity of output of that good. That is what we are asking here is that when the input increases like this. How does the output increase? So, here we have it in the form of a table, but we can plot it in the form of a production function.

The production function is telling us that as the number of workers increases, the output increases from 0 to say around 160, but the shape of the curve is telling us that earlier when the number of workers was increasing the output increases at a much faster pace, but later on it is now getting more and more leveled which is another way of showing the law of diminishing marginal product.

The increase in the output at this point because of an additional worker is much less than the increase that we were getting at this point. So, typically the production function looks like this. Earlier we have a large increase in the output when the input is increased, but later on it becomes more and more flat enough and we can also plot the total cost curve now total cost.

If the output increases there will also be a change in the total cost. Why? Because in any firm we have a certain fixed cost now fixed cost will remain the same for any amount of output. So, even when the output is increasing from 0 to 155, the fixed cost remains the same, but then to increase this output we are also employing certain labour, certain workers.

The cost of these workers will go on increasing with the number of workers because, say the wage rate is 10 units of money per worker. So, if only 1 worker is employed then the cost of the worker is 10, if 2 workers are there then the cost is 20, 6 workers are there the cost is 60.

This is a variable cost that we have. So, we have fixed cost here variable cost and the sum of the fixed cost and the variable cost will give us the total cost. So, when no worker is being employed then the fixed cost is 30 rupees, the variable cost is 0 rupees and so, the total cost becomes 30 when 1 worker is employed then fixed cost plus 30, the variable cost is 10, and so, the total cost increases to 40 and so on.

In this particular example we are not talking about the cost of the other inputs because we are looking at only one input. So, the total cost increases as the output increases and with this we can plot the total cost curve. Now here on the x axis we have the output. It increases from 0 to close to around 160 and we have the total cost.

As the output increases the cost also increases mainly because of the variable cost because the fixed cost remains the same, but the variable cost increases, but in the case of the total cost curve we will observe that the curve starts in a flatter manner and then it starts to increase at a very fast rate. Because here again what we are observing is that because of the law of diminishing marginal product to increase the output from 140 to 160 we will require a very great amount of input.

Because now the inputs are not working that hard, they are not giving that high an output whereas, when we increase the output from 0 to say 50, the costs involved are really less because the inputs are putting up a very large amount of output.

As the inputs are increased their marginal product decreases because of which for any additional amount of output we will need to put up a very large amount of input which would also mean that we would have to spend a very large amount of money. So, the total cost increases, it increases more gradually in the beginning, but later on it increases at a very fast pace. So, this is the total cost.

And total cost includes the fixed cost and the variable cost. Fixed costs are costs that do not vary with the quantity of output produced such as the cost of rent, the cost of security and so on. Whether the firm produces 0 samosas or whether it produces 150 samosas in an hour the rental cost of land will remain the same.

The cost of security will remain the same because even when the production is going up you do not have to employ a larger number of security guards, but even when you are not doing any production, you will still require the security guards to protect the equipment to protect the premises.

The cost of security is a fixed cost. Then we have variable costs. Costs that vary with the quantity of output produced such as the cost of raw materials, the cost of wages and so on. So, if the firm is producing less number of samosas it requires less number of potatoes, it requires a lesser quantity of maida, it requires lesser number of workers, it requires lesser amount of electricity, but when it is producing a larger quantity of samosa, then it requires a larger quantity of all of these.

This is a variable cost: a cost that varies with the quantity of output that is produced. Total cost is

fixed cost plus marginal plus variable cost and marginal cost is the increase in total cost that arises from an extra unit of production. So, what we are asking in the case of marginal cost is that, if you increase the output by 1 unit if you want to increase the output by 1 unit what is the cost involved to increase that? Now the cost in this case is smaller and the cost to increase 1 unit of production in this case is much larger.

The marginal cost in this case is increasing with the output. So, marginal cost is the increase in the total cost that arises from an extra unit of production. Now we take a firm example. Let us look at the cost of a firm that is making coffee and in this case when the number of coffee cups per hour increases from 0 to 10 the fixed costs remain the same, the variable cost goes on increasing and the total cost is given as fixed cost plus variable cost.

In this case for 0 cups of coffee we have a fixed cost of 3, variable cost of 0. So, total is 3 for 1 cup of coffee, the fixed cost is 3, the variable cost is 0.3. So, the total cost is 3.3 for 2 cups of coffee that becomes 3.8 and so on. This is the total cost. The marginal cost is the cost of increasing 1 unit of the output. From 0 to 1 when the number of coffee is increased from 0 to 1 the total cost increases from 3 to 3.3.

And so, the marginal cost of 1 cup of coffee in this case is 0.3. 3.3 minus 3 is 0.3, but when it increases from 1 to 2 then the total cost increases from 3.3 to 3.8 which means a marginal cost of 0.5 when you subtract 3.3 from 3.8 you get 0.5. So, here the marginal cost is 0.5. The cost of making an additional cup from 2 to 3 is 0.7. So, here we are observing that the marginal cost is increasing.

If we plot these costs we will find that the fixed cost remains the same, say 3 rupees, whether the firm is making 0 cups of coffee or it is making 10 cups of coffee. So, the fixed cost remains the same; it is a flat line. The variable cost shown in green increases with the number of cups because with more cups you require more sugar, more water, more milk, more coffee.

The variable cost goes on increasing. If you look at the total cost then total cost because it is the sum of the fixed cost and the variable cost it will also increase because fixed cost is the same variable cost is increasing and so, total cost will also increase. And when we look at marginal cost we are asking the question: what is the difference from this point to this point in terms of cost?

What is the difference from this point to this point in terms of cost? And in this case we are observing that the marginal cost is increasing. To make an additional unit of coffee an additional cup of coffee the costs are increasing. Earlier we required a lesser cost to make a cup of coffee or to increase the production of coffee by 1 unit, but later on we require much more money to make an additional cup of coffee.

Now, this is because of the law of diminishing marginal product because our inputs that we are buying from uh the cost they will not be giving out that large an output. So, these are the costs. Now we can also look at the average cost. So, we have the average fixed cost which is the fixed cost divided by the quantity of output.

In this case the fixed cost is the quantity of output when it increases we can find out the average fixed cost, another one is average variable cost which is the variable cost divided by the quantity of output. The third is the average total cost which is the total cost divided by the quantity of out-

put and the fourth cost is the marginal cost which is the change in the total cost divided by the change in the quantity of output.

In this case we have a fixed fixed cost, we have an increasing variable cost and so, the total cost is also increasing. Now in finding out this uh average cost, for average fixed cost we do 3 divided by 1 is 3 in the next line we have 3 divided by 2 is 1.5. So, the fixed cost is remaining the same. So, in this case the numerator remains the same fixed cost, but the denominator is increasing.

And so, the average fixed cost rate goes on decreasing. What about the variable cost? The variable cost for making 1 cup of coffee is 0.3. So, the average is 0.3 to make 2 cups of coffee it is 0.8. So, the average variable cost is 0.8 divided by 2 is 0.4, to make 3 cups of coffee the variable cost is 1.5. So, the average is 1.5 divided by 3 is 0.5 and so on.

And here we are observing that the average variable cost is increasing. Now the average variable cost is increasing because of the law of diminishing marginal product. Now if we look at the average total cost. So, we have this total cost divided by the number of cups of coffee. So, 3.3 divided by 1 is 3.3 1.5 3.8 divided by 2 is 1.9, 4.5 divided by 3 is 1.5 and so on.

Average total cost is the total cost in that particular row divided by the number of cups of coffee and that would give us the average total cost. Marginal cost is an increase in the total cost divided by the increase in the number of cups of coffee. So, for each increase for each additional cup of coffee what is the cost involved?

Here we can find out the marginal cost by dividing the value in this row by the value in the previous row. So, 3.3 minus 3 is 0.3 3.8 minus 3.3 is 0.5 4.5 minus 3.8 is 0.7 and so on. So, in this case we can find out the average fixed cost, the average variable cost, average total cost and the marginal cost.

This is how it looks when we plot them. The red curve is showing us the average fixed cost. Now the average fixed cost goes on decreasing. The average fixed cost decreases from 3 to 1.5 to 1.1 and so on. It is going to decrease, which is what we are observing here. The average fixed cost is going on decreasing, but earlier the decrease is very large and later on the decrease is much lesser.

Now, this is because in the case of the average fixed cost is the fixed cost divided by the amount of output. Now earlier what we are seeing is 3 divided by 1 or it is 3 divided by 2 and 3 divided by means 3, 3 divided by 2 is 1.5. So, there is a large change from 3 to 1.5, but when we do say 3 divided by 9 and 3 divided by 10. So, 3 divided by 9 is 1 by 3 is 0.33 and 3 divided by 10 is 0.3.

Here the change is very less the the change is the only 0.03 whereas, here the change was much larger it was 1.5, which is what we are observing here in this curve that earlier the fixed cost it decreased by a very large amount, but later on the change is very less because the denominator is increasing the numerator is kept fixed the denominator is increasing and the impact of this increase in denominator will be much built in the beginning than at the later stages.

The average fixed cost goes on decreasing. The average variable cost and the marginal cost go on increasing with the number of cups of coffee per hour because of the law of diminishing marginal product. Now to make each additional cup of coffee we require more of the inputs because now the inputs are not working that hard and that would increase both the marginal cost and also

the variable cost.

The variable cost and the marginal cost go on increasing. The average total cost decreases in the beginning and later on it increases. Now the decrease in the beginning is because of the decrease in the average fixed cost. Now what we are observing here is that the total cost is equal to the fixed cost plus the variable cost.

The average total cost is the total cost divided by the output. So, if we divide the whole of the additives also by output we will get this. Now TC/Q is the average total cost is equal to the fixed cost by Q is the average fixed cost plus the $VC/2$ is the average variable cost. So, the average total cost is equal to the average fixed cost plus the average variable cost.

As the number of cups of coffee increases we find earlier a very great decrease in the average fixed cost. The average fixed cost decreases very quickly, but at later stages it will decrease at a very less amount. So, we can say that after a while it will tend to become constant, but earlier it decreases very fast.

But the second component is the average variable cost. Now the average variable cost goes on increasing. Now in the beginning when we look at the average total cost the average fixed cost is very high the average variable cost is very less. So, in the beginning what we are observing is that in the beginning the average fixed cost is very much greater than the average variable cost.

The average fixed cost shown in rate is very much greater than the average variable cost and so, the average total cost is roughly equal to the average fixed cost because in this case we can neglect the average variable cost. But later on what happens, the average variable cost becomes very much greater than the average fixed cost which is what we are observing here.

The average variable cost because the average variable cost has been increasing with more cups of coffee, it has increased to a large value whereas, the average fixed cost has continued to decline in its value. So, later on the average fixed cost is less, the average variable cost is very high and so, we can write that the average total cost is approximately equal to the average variable cost.

Because later on we can say that we can neglect the average fixed cost because the average variable cost is very high. So, we can neglect the average fixed cost.

Now, in the beginning what is this telling us, if we look at the curve in the beginning the average total cost is roughly equal to the average fixed cost which means that when the average fixed cost decreases then the average total cost also decreases because it is roughly equal. So, the average total cost is roughly equal to the average fixed cost because we can neglect the average variable because they are very less.

In this case when the average fixed cost will decrease the average total cost will also decrease, but later on the average variable cost are high and the average fixed cost are less and so, the average total cost is roughly equal to the average variable cost which means that, when the average variable cost increases the average total cost will also increase.

In this case we can see that in the beginning the average total cost shows a decreasing trend, but later on it shows an increasing trend which is what we are observing here the average total cost earlier it shows a decreasing trend, but later on it shows an increase in trend which means that there is some point somewhere that is the minimum of the average total cost. Because before this

point we are observing that it is going down. After this point it is increasing which means that there should be a minimum.

What we can see here is that the marginal cost rises because of the diminishing marginal product, the average fixed cost decreases because of fixed cost by increasing the quantity of output, the average variable cost rises because more inputs are required for the output, but the average total cost is U-shaped because earlier it lowers because of reducing average fixed cost and later on it rises because of the increasing average variable cost.

And the point where we have the minimum of the average total cost that gives us the efficient scale. Efficient scale is the quantity of output that minimizes the average total cost which means that when you look at this curve, then this point. So, at this point the average total cost is minimum.

This quantity, which is 6 cups of coffee, we will say that this is the efficient scale because this quantity of output minimizes the average total cost. So, the average total cost is the least at 6 cups of coffee, but then how do we reach this lowest value? Is there any correlation between all of these costs?

So, we can find out that the relationship between the marginal cost and the average total cost is that the marginal cost curve cuts the average total cost curve at the efficient scale where the average total cost is the minimum. Now why is that so? When we talk about the marginal cost, the marginal cost is the cost of producing an extra unit of coffee, the increase in cost for making one more cup of coffee. Now in this case before this point say. So, to the left of this point the marginal cost is less than the average total cost which means that if one more cup of coffee is produced then the average total cost will further reduce.

Whereas, to a point to the right of this the marginal cost is more than the average total cost. So, when the marginal cost is more it means that to make an extra cup of coffee it will now cost more than the average total cost which means that at this point to the right of this efficient scale, we will find that the average cost will increase.

It is decreasing here, it is increasing here. At this point where both of these curves are, it should be the minimum of the ATC line. So, the marginal cost curve cuts the average total cost curve at the efficient scale where the average total cost is the minimum because to the left of this point the marginal cost is less than ATC and the ATC is falling to the right of this point because it has cut here.

To the left it is less than ATC, to the right it is more than ATC. To the right of this point the marginal cost is greater than ATC and the ATC is rising. To the left it is falling to the right it is rising. So, the point has to be the minimum. This is the relationship between the marginal cost and the average total cost curve, that the marginal cost curve cuts the average total cost curve at the efficient scale.

And this also brings us to the economies and diseconomies of scale. Economies of scale is the property whereby the long run average total cost falls as the quantity of output increases which means that when we talk about economies of scale it makes more sense for the company for the firm to produce more output because when the output is more the long run average total cost falls a good reason is because of specialization.

So, different components that are required to make the product are brought together and so, the output increases. Diseconomies of scale is the property whereby the long run average total cost rises as the quantity of output increases because of problems in coordination and a constant return to scale is the property, whereby the long run average total cost stays the same as the quantity of output changes.

What we are saying here is that, in the case of certain firms which show economies of scale, what happens is that with more production, more and more specialization is brought in which increases efficiency because of which the average cost further reduces. So, the larger the firm, the lesser the average cost in the case of diseconomies of scale the larger the firm the larger is the problem of coordinating different units and so, the larger it becomes the more the cost will rise. So, different firms will show different tendencies, some will show the economies of scale, some will show diseconomies of scale and some others will show a constant rate return to scale.

To summarize, costs determine the levels of profits. At the market equilibrium the firm with the lowest cost will have the largest profits and will be a winner in the competition between different firms which is why every firm wants to be a winner and so, it tries to lower the cost.

And this is the reason why firms try to cut the cost even at the risk of environmental damage.

That is all for today. Thank you for your attention. Jai Hind!

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Module 9
Industrial organisation and Conservation
Lecture 2
Competition

Namaste! We move forward with our discussion on Industrial Organization and Conservation and in this lecture, we shall have a look at Competition. So, we will begin with a recall. Rational decision making is based on cost benefit analysis which is a study that compares the cost and benefit of providing a good or a service.

What we are saying here is that rational decision making, which is the basic assumption that we make in the case of theoretical economics, it says that the rational decision making is based on a cost benefit analysis; what is the cost of doing something and what is the benefit that we are going to receive by doing that activity.

This brings us to the concept of profit and profit is defined as total revenue minus total cost. For a firm the profit is the benefit. When the firm is making a decision which is a rational decision, then it bases its decision on the amount of profit that it is going to receive.

We also had a look at a competitive market. Competitive market is a market in which there are many buyers and many sellers so that each has a negligible impact on the market price. Essentially what happens in the case of a competitive market is that there are so many buyers.

And so many sellers that any one buyer or a group of buyers or any one seller or a small group of sellers is not able to make a big change in the market prices. Which means that, these people are price takers, that is the buyer will have to take the price that is being offered in the market and the seller will have to sell at the price that is being offered by the market.

We also had to look at the characteristics of perfectly competitive markets 1 - goods offered for sale are exactly the same. 2 - there are so many buyers and sellers that no single buyer or seller has any influence over the market price; all buyers and sellers are price takers.

This is a very important statement that you should remember that in a competitive market all the buyers and sellers are price takers. At the market price, the buyers can buy all they want and the sellers can sell all they want and this is because there are so many buyers and sellers that if a buyer is ready to procure the goods at the market price.

Then there are so many sellers that he can buy an indefinite amount of goods and similarly if there is a seller who is ready to sell things at the market price, then there are so many buyers that he can sell as many things as he wants. Then another characteristic is perfect information transfer regarding prices which means that the buyers and the sellers know at all times what the prevail-

ing market prices are.

Now, this is very important because the buyer is not spending time and energy and effort in finding out at what rate different sellers are selling the things. So, he gets this information in an instant. So, this is an assumption that we make in the case of a competitive market. Similarly, the seller knows at an instant what is the price at which different buyers are ready to buy the goods. When that happens the biggest thing is that the seller can sell the goods to the buyer who wants to pay or who is ready to pay the maximum amount. And, because this thing can happen in an instant so, if there is any buyer who wishes to buy at a price that is greater than the market price, then so many sellers will be ready to supply him the goods that it will bring his price down.

Which means that, suppose, I go into the market in a fairly competitive market, and I see that there is this pen that is being offered. Now, I am ready to pay as much as 20 rupees for this pen, but the prevailing market price is 15 rupees.

If I say that I want to purchase 20 pens for 20 rupees each. What will happen is that there will be so many sellers who will be ready to supply me these pens at 20 rupees that I will start to think that ok if 20 probably I am offering them a bit too high a price. So, let me offer them 19 rupees because at 20 rupees there are so many sellers.

So, basically I can have say lakhs and lakhs of pens for 20 rupees and remember that the goods that are being offered are the same, that is they have the same quality. So, when I am offering 20 rupees there are a very large number of sellers and I have so many pens that I can purchase.

Similarly, at 19 rupees, a few sellers would go away because their cost of production is greater than 19 rupees. So, in that case those sellers will go away, but still I have a very large number of sellers and then I will bring my cost down to 18 rupees, then 17, then 16, then 15, and even at 15 rupees I am finding that there are so many sellers who are ready to sell me the product.

But, then when I bring it to a value that is less than 50, less than the market price say I say that I am going to pay 14 rupees and 99 paise and that case I will find that there is no seller who is ready to offer me this pen for 14 rupees and 99 paise and why is that so?

Because there are so many different buyers that there will be some buyers who will be ready to pay 15 rupees. So, the seller in that instant will shift away from me and offer the goods to the other buyer. That is, at any price that is less than the market price or the market equilibrium price, there is no seller who is ready to give me the goods.

And, at any price that is equal to or greater than the market price I can have as many goods as I want and so, the equilibrium is reached very fairly quickly because there is a free flow of information in an instant. So, if I offer anything more than 15 rupees there will be so many sellers that I will think because here again I am a rational decision maker.

Every buyer and every seller is said to make the decisions on a rational basis. So, when I am offering 16 rupees and there are so many sellers I will start with this question that ok can I bring my welfare up? Because the consumer surplus is determined by the price that the buyer is going to pay if I am paying a higher price, then my consumer surplus is less.

So, I will try to bring down the price to increase my consumer surplus and so, I will move from 20 rupees to 19, 18, 17, 16 and 15. But, then at any price that is less than 15 rupees I will find no sellers because they will be offering their goods with the other buyers and in that case in a very

quick instant I am able to reach the market price and, similarly in the case of a seller.

Now, if there is a seller who is ready to sell the pen at the market price that is 15 rupees he or she will find n number of buyers. If the seller is ready to sell the product at 14 rupees, then he will have so many buyers that again with the rational thinking the seller would start to think ok can I increase my producer surplus.

And, the producer surplus of the seller would increase when the price goes up. So, at 14 rupees the seller would say that ok there are so many buyers, let me offer them 14 rupees 50 paise. He will still find so many buyers, then he will slowly and steadily bring the price up to 15 rupees and even at 15 rupees there are so many buyers.

But when he increases it from 15 rupees to 15 rupees 1 paise, suddenly there are no buyers because all the buyers are ready to buy the product from the other sellers because remember there are so many buyers and so many sellers. And, so, this criterion of a very fast moment of information ensures that the competitive market works properly.

So, this is again a very important criteria. A perfect information transfer regarding the prices and when we say perfect it is not just accurate, but it is a keep information transfer and a fast information transfer. Then there has to be well defined property rights. Free entry and exit into and from the market.

Because if there are buyers who find that the prices are too high, then they can go out; if there are buyers who are ready to buy at this price, they can enter into the market there is no restriction. Similarly, the sellers who find that their costs are less than the market prices so, they can earn a profit they will enter into the market.

Those sellers whose cost of production is very high will exit from the market. So, in the case of a competitive market because we have a very large number of buyers and sellers and we want to maintain that condition. So, there is also a free entry and exit from the market. Then there is rationality: both buyers and sellers try to maximize their utility and there are zero transaction costs. And, when we say zero transaction cost it means that as a buyer if I go from one seller to another seller it should not be the situation that one seller is near to me and another seller lives 10 kilometres away. Because in that case the cost of moving from point A to point B will also enter into the computation.

And, so, when we are making the model of a competitive market we say that there are no transaction costs. The buyer and the seller are able to reach each other; make all their negotiations in an instant without paying any amount for it.

So, there are no transaction costs, no cost of moving from one place to another and no cost of getting the information or transmitting the information. This is what a competitive market or a theoretical competitive market on a model of competitive market will look like. So, these are the characteristics.

And, we also saw that competition is beneficial because it permits everyone to specialize in what they have the highest comparative advantage in. And, comparative advantage is the ability to produce a good at a lower opportunity cost than another producer.

Now, when people are doing a specialization and they are producing things in a way that they have the highest comparative advantage in effect it brings down the prices. So, it increases the

efficiency because different people have a comparative advantage in doing different things and through the specialization people do what they have the highest comparative advantage. So, in effect it brings down the prices for everybody.

Second, competition increases efficiency or the property of the society getting the most it can from the scarce resources. Now, this is because people are doing what they have the highest comparative advantage in which means that they are doing everything very efficiently and so, the cost of producing anything is very less.

So, the resources that the society has are able to generate the largest quantity of goods and services. So, which is beneficial to the society and specialization and efficiency reduce prices which also benefits the consumers.

Now, let us talk about how a firm is going to decide how much to produce, at what rate to produce and how to produce. Now, we have seen before that whenever a firm is doing production, they do it through rational decision making looking to maximize their profits.

That is they want to sell at the highest prices and make things at the lowest possible prices maximizing their profits and profit is total revenue minus the total cost of production. Now, total revenue is given as TR or total revenue is equal to P into Q, where P is the price at which the goods are sold and Q is the quantity of goods that are sold.

Essentially if there are say 100 pens that are sold at 20 rupees each, then we will have that 100 pens is Q and 20 rupees is P and the total revenue is given by P into Q which is 20 into 100 is 2000 rupees. So, this is how we find the total revenue. Total revenue is P into Q.

Average revenue is defined as average revenue is total revenue divided by the quantity of goods sold, AR is TR divided by Q. Now, average revenue is more used when we are talking about a situation when goods are sold at different prices.

Basically if we say that out of these 100 pens we had say 90 pens that were sold at 15 rupees and if we say that we have 10 pens that were sold at 20 rupees. In that case total revenue would be 15 into 90 plus 20 into 10. This would be total revenue and average revenue would be given as total revenue divided by the quantity.

In our case what we are saying is that the price is constant. So, in this case when we write the total revenue is P into Q. And, average revenue is total revenue divided by Q, then we will find the total revenue divided by 2 is P into 2 divided by 2 which is P.

So, the average revenue is the price at which the goods are being sold. Now, this is something that is applicable in the case of a competitive market because the price is constant. But, in the case of other markets we will have an average revenue that is different from the price.

Then we also have marginal revenue, the change in the total revenue from an additional unit sold. In this case, the question that is being asked is that the seller is selling 100 pens at 20 rupees each. Now, if the seller in place of selling 100 pens is now selling 101 pens, and suppose, the 101 pens are sold at 21 rupees.

In that case the marginal revenue will be given by difference in the total revenue divided by difference in the quantity. In this case, this. What we are saying here is that the total revenue earlier, let us say that we are writing TR one is 100 into 20 is 2000.

Total revenue 2 is when the seller is selling 100 pens for 20 rupees and 1 pen for 21 rupees. So,

the total is 2021 rupees. Now, in this case delta TR will be given by TR 2 minus TR 1 is 2021 minus 2000 is 21 rupees. So, the change in the revenue is 21 rupees and the change in the quantity is 101 pens minus 100 pens which is 1.

In this case the marginal revenue will be given by 21 rupees. Now, this is a theoretical construct, but when we are talking about a perfectly competitive market in that market everybody is a price taker. The seller is a price taker.

The buyer is also a price taker which would mean that the 101 pens will also be sold for 20 rupees and in that case the marginal revenue will also be 20 rupees which is equal to the price. So, marginal revenue is the change in the total revenue from an additional unit sold delta TR divided by delta Q.

In the case of a perfectly competitive firm we will have average revenue is equal to marginal revenue is equal to the price. Because in this case what will happen is that average revenue is total revenue divided by quantity is P into Q divided by Q is equal to P .

And the marginal revenue is delta TR divided by delta Q is equal to TR for selling n plus 1th item minus TR for selling n th item divided by n plus 1 minus n . So, delta TR is the total revenue for selling the larger number of quantities minus total revenue for selling the smaller number of quantities.

And, in this case we are talking about the change in the revenue by selling one extra item. So, earlier the seller had sold n items and now, he is selling n plus 1 items, which is why we are having TR_n plus 1 minus TR_n .

In this case total revenue for selling n plus 1 items will be P into quantity which is here n plus 1 minus TR for n items is P into n divided by n plus 1 minus n is 1 which in turn becomes. So, this now becomes P n plus P minus P n divided by 1. Now, P n and P n get cancelled is equal to P .

What we are finding is that AR is equal to P and MR is also equal to P . So, in total what we can write is that AR is equal to MR is equal to P . Average revenue is the same as the marginal revenue which is equal to the price at which the goods are being bought and sold.

This is one example. In the first column we have the number of samosas that are being sold and the price of each samosa is 6 rupees. Now, when we have this chart the total revenue given by TR is equal to P into Q .

When Q is one then total revenue is 1 into 6 is 6 ; when 2 samosas are sold then total revenue is 2 into 6 is 12 ; when 3 samosas are sold then it is 3 into 6 is 18 and so on. So, in this column we have the total revenue. The average revenue is given by TR divided by Q .

So, here we have TR divided by Q 6 divided by 1 is 6, 12 divided by 2 is 6, 18 divided by 3 is 6 and so, we are finding that average revenue is equal to 6 rupees in each case which is equal to P . So, P here is 6 rupees and here we are finding that this all is also equal to P .

In the case of marginal revenue it is delta TR divided by delta Q . So, delta TR is the difference between this TR and this TR 12 minus 6 is 6 divided by delta Q is an increase of 1. So, 12 minus 6 is 6 18 minus 12 is 6 24 minus 18 is 6.

And so, here we are also observing that in each of these the MR is equal to the price. So, for a competitive firm that is a price taker the average revenue is equal to the marginal revenue is equal to the equilibrium price in the market at which the goods are being sold.

Now, the thing is that when a firm is making the goods and is telling the goods the aim of the firm is the maximization of the profit. So, we saw this in the case of the cost benefit analysis. The benefit to the firm is the profit and the firm is trying to maximize the benefit. So, how can the profit maximization be done?

Now, when we talk about profit maximization we need to remember that marginal revenue is fixed which is given by the price. So, here we have observed that the marginal revenue is equal to price, but when more and more quantities of goods are being produced the marginal cost increases.

And, we have observed that the marginal cost increases because of the law of diminishing marginal product which means that for every additional unit of item that is being produced, the inputs do not work that hard. The efficiency goes down.

So, the marginal cost increases when more and more products are being manufactured whereas, the marginal revenue will remain the same as P. Now, in such a scenario here we are observing that in this column we have the number of samosas that are sold.

This is the price, this is the total revenue and the marginal revenue is 6 in each case, but the marginal cost increases. So, let us say that the marginal cost increases like this 2 3 4 5 6 7 8 9. So, this is the marginal cost. Now, we can also talk about the total cost and total cost is equal to the fixed cost and the variable cost.

What we are saying here is that total cost is equal to the fixed cost plus the variable cost. But, we can also write that total cost is equal to say at stage n plus 1 is equal to total cost at stage n plus the marginal cost for n plus 1.

This means that at every step of computing the total cost we can use the total cost in the previous step and the marginal cost. Now, marginal cost as we have seen it goes on increasing. So, in this table we are observing that the marginal cost is increasing and the total cost.

So, the total cost for selling 0 items would be the fixed cost which in this case is 3 rupees. And, for every step we can do a computation by adding marginal cost to the total cost in the previous step that we had seen here.

The total cost at any stage say that nth stage is the total cost in the previous stage plus the marginal cost at that particular stage. So, if the total cost for this point is 2 plus 3 is 5, for this cell it will be 3 plus 5 is 8, for this cell it is 4 plus 8 is 12, for this cell it is 5 plus 12 is 17 and so on. So, this is the column for the total cost.

Now, profit is defined as total revenue minus total cost. So, we are taking this total revenue minus total cost. So, 0 minus 3 is minus 3 rupees, 6 minus 5 is 1, 12 minus 8 is 4, 18 minus 12 is 6 and so on. Now, in this case we can observe that the profit when 0 items are sold is negative.

Because the total revenue in this case is 0 because no items are being sold, but still the fixed costs need to be paid. So, in this case the profit is negative. Then the profit increases reaches a maximum and then starts to decrease and we are observing the change in the profit which is given as marginal revenue minus marginal cost.

Now, in the case of change in profit what we are asking is if one more item is being produced and sold, what is the change in the profit? So, when one more item is sold, the revenue that the firm will be getting is the marginal revenue.

But the cost of producing it will be the marginal cost for that particular item. What we are asking is the firm has already sold n items and it wants to sell now $n + 1$ items. So, for this one item that the firm wants to sell, what is the marginal revenue? What is the marginal cost? Now, the difference will give us the change in the profits.

The marginal revenue minus marginal cost: here you have marginal revenue, here we have the marginal cost. Marginal revenue is fixed, marginal cost is increasing. So, when we subtract marginal cost from marginal revenue we start from a large value.

But this value goes on decreasing because MC is increasing whereas MR is constant. Here we are observing that the change in the profit is reducing, that is when the firm is producing larger and larger amounts of products, then after a while the change in the profit will become negative which means the profits will start to decrease.

If we plot these values we will find a curve like this. So, the first thing is the price which is shown here at this blue line and the price in this case is constant. It is fixed at 6 rupees. So, this is what we are talking about: the price is fixed and so, we are getting a straight line, this straight blue line is the price line.

The total revenue is proportional to the quantity that is shown because total revenue is given as total revenue is P into Q . Now, because P is constant it is a straight line so, total revenue is proportional to the quantity of goods that have been sold and which is what we are observing here.

In the case of this green line the more is the quantity the more is the total revenue and it is a straight line because it is proportional to Q and the proportionality is a fixed constant. Then the total cost increases with the rising marginal cost.

The total cost is shown here in the red curve. So, the total cost is increasing, but then the rate of increase also goes on increasing, which means that earlier there is a very small change in the total cost with more and more items that are being produced the change is much larger and this is because of the law of diminishing marginal product.

Now, with more and more quantities that are being made the efficiency of the inputs reduces which means that for producing an extra quantity of the good more cost needs to be put in. And, so, we are observing a curve that increases like this.

Now, the total cost curve shown in red does not start from 0, but it starts from a finite value and that finite value is the fixed cost. So, when 0 quantities of things are being produced and sold, even then there are certain fixed costs and those fixed costs will show themselves in the total cost.

Next we can have a look at the profits. Now, profit increases reaches a maximum value and then starts to decrease which is this black line. Now, the profit is given by total revenue minus total cost. The difference between both of these is the profit.

Where both of these are roughly the same we will have a profit of 0 or near to 0 when the difference is large, then we will have a larger amount of profit. So, profit goes to a maximum and then it goes on decreasing and profit is maximum where the price is equal to the marginal cost. So, what we are saying here is that if you plot the profit.

This is the profit and the profit reaches a maximum and the profit reaches the maximum where the price is equal to the marginal cost. Now, the marginal cost is shown here. So, this is marginal

cost and it is increasing and at the point where it touches the price curve and price is a straight line which is equal to marginal revenue. So, at this point the profit is maximum. Now, why is that?

The thing is to any point to the left of this point this is our point that we are interested in and at any point to the left we have a situation where the marginal revenue which is given by the price is greater than the marginal cost.

What we are saying here is that at points on the left, the marginal revenue which is equal to price is greater than the marginal cost. Now, if the marginal revenue is greater than the marginal cost it means that if one more item is produced, then the cost of producing that item is less.

But, the increase in the revenue that we will get will be greater which means that the production of any extra item will add to the profit. Because for all of these points the margin and revenue is greater than the marginal cost. So, if one more item is produced we will get a larger amount of revenue, but the increase in cost will be lesser.

So, for any such point it makes sense to produce more items. So, it makes sense to move to the right. So, for all the points to the left of this point, it makes sense to move to the right. But, for any point to the right of this fixed point ; so, we are talking about this point.

At any point to the right, what is the situation? We have a situation where the marginal cost is greater than the marginal revenue which means that when any further item is produced, then it costs more to produce that item than the increase in the revenue that we will get by selling that item.

Which means that the more the items that are produced the less the profits will become which means that it does not make any rational sense to make that item. So, at any point to the right of this point we will come to the conclusion that no, we are already making a bit too much and we should be making a bit less.

All these points will try to move to the left, all these points will try to move to the right and they will reach to this point. So, for all the points to the left what we are saying is that if we increase the number of items, then we can increase the profit for all the points on the right.

We are saying that we are already making a bit too much. We should reduce the quantity and so, this will be the quantity at which the profit will be maximized. So, profit is maximum where P is equal to MC which is the price is equal to the marginal cost of production.

We can also say that profit is maximum where MR minus MC is equal to 0 because marginal revenue minus marginal cost is equal to 0 that is this is the marginal revenue line which is the price line and this is the marginal cost line. And, we are saying that profit is maximum where the difference is 0.

That is, if this is the difference then and if you take another point, say this point so, we are taking these two points. Now, at this point there is a certain amount of profit because the margin and revenue is greater than the marginal cost, but if more items are produced here again we are getting a profit because the marginal revenue at this point also is greater than the marginal cost of production and similarly at this point.

For all of these points, the marginal revenue is greater than the marginal cost, but once we cross this point we will reach a point where the marginal cost of production is greater than the mar-

ginal revenue that we will get. After this point we should stop producing any more items because if we cross this point.

Then we will reach a stage where it costs more to produce the goods and we will get a lesser amount of revenue in return, that is, the profit will go down. So, the profit is maximum at the point where this difference is 0 because if this difference is greater than 0.

Then there is still a scope to produce more items and get more profit. Whereas, if this difference is negative then it means that we are already producing a bit too much. So, the point at which this difference is 0 is the point of the maximum profit which is what we are observing here.

So, this is the point of the maximum profit. Next we can also say that profit is maximum at the peak of the profit curve which is very obvious because when we are reaching the peak of the profit curve that is the maximum profit after that the profit will decrease.

Now, the next thing is that we can have a maximum profitability, but how do we maintain that profitability for a long period of time? That is the next question that we need to analyse. So, if you look at this chart we have the number of samosas that are sold, the price and the price is fixed.

The marginal cost increases; the total cost also increases; the fixed cost is fixed and fixed cost is given by the total cost for 0 production which is 3 rupees. Now, the difference between the total cost and the fixed cost will give us the variable cost.

For 0 items it is 3 minus 3, 0; for 1 item it is 5 minus 3 is 2; for 2 items it is 8 minus 3 is equal to 5. So, we can compute the variable cost and the variable cost is equal to total cost minus the fixed cost and this is because total cost is fixed cost plus variable cost.

We can compute the variable cost in this manner. Now, with this we can also compute the average total cost and the average variable cost. Average total cost is total cost which is this value divided by the quantity that is sold.

Total cost here is 5 divided by 1 is 5, for this value it is 8 by 2 is 4, then 12 by 3 is 4, then 17 by 4 is 4.25 and so on. So, this is the average total cost. We also have the average variable cost which is variable cost divided by the quantity sold.

Here it is 2 by 1 is 2, then 5 by 2 is 2.5, then 9 by 3 is 3, then 14 by 4 is 3.5 and so on. So, we can compute the average total cost and the average variable cost. Now, the thing is when we plot these values together.

We have a fixed price which is equal to the marginal revenue, we have a marginal cost that goes on increasing and we have observed that the firm earns the maximum profit where the marginal cost is equal to the price which is what we have seen before.

Profit is maximum where P is equal to MC in this case when P is equal to MC we are getting the maximum profit. Now, if you look at the average total cost it decreases and then it increases. And, we have observed this before because when we look at the total cost.

Now total cost is fixed cost plus variable cost. Now, the average total cost will be given by total cost by Q is equal to FC by Q plus VC by Q . Now, in this case, the FC is a fixed value because this is a fixed cost whereas, the variable cost goes on increasing.

Now, if we look at our chart the average total cost reduces and then it increases whereas, the average variable cost goes on increasing. Now, why does the average total cost reduce first because

the average total cost is this value plus this value.

Now, in the beginning when we have a very low quantity of goods that are being produced then we have a substantial amount of fixed cost, but the variable cost is very close to 0 because we are not producing anything. So, what we get here is that in the beginning the fixed cost is very much greater than the variable cost which means that $FC \text{ by } Q$ is very much greater than $VC \text{ by } Q$.

And, in this case, we can say that the average total cost is approximately equal to $FC \text{ by } Q$ because FC is very much greater than VC . So, we can neglect this term and we can say that average total cost is roughly equal to $FC \text{ by } Q$. Now, FC is fixed because this is a fixed cost, Q when it goes on increasing the average total cost will go on decreasing.

So, in the beginning what we observe is that the average total cost, it goes on decreasing. Because here the fixed cost is more, the variable cost is very small and with increasing quantity of goods the average fixed cost goes on decreasing. But, then at a later stage we will find that average total cost is total cost by Q is fixed cost by Q plus variable cost by Q .

So, later we will find that the variable cost has increased and so, the variable cost is now greater than the fixed cost. When that happens, we can write that $TC \text{ by } Q$ or the average total cost is approximately equal to $VC \text{ by } Q$ because in this case we can neglect this term because this is now very much less than $VC \text{ by } Q$.

So, average total cost in this case is approximately equal to $VC \text{ by } Q$ which is equal to the average variable cost and what we have observed here is that the average variable cost goes on increasing. So, in the later stages we will find that the average total cost also goes on increasing and this black line is showing us the average variable cost which is increasing. So, we have observed that this is the point of the maximum profitability.

But, then we can also talk about profitability in the long run. Now, in the long run what we are saying is that if this is the average total cost and if this is the price that we get as long as the price is greater than the average total cost we should be producing the goods.

Which means that, the cost of production is less, the selling price is more, so, there is some profit. It may not be a very large profit, but there is some profit. And, so, we should continue the production in the long run if the price is greater than the average total cost.

We will continue to produce goods till this point where the price is greater than the average total cost. After this point the price is less and the average total cost has increased. Now, we are moving into a point of loss and so, we should not cross this point, but this is the point for long term profitability.

In the long run a firm should shut down if the revenue is not able to meet the total cost of running because here again the firm is making decisions based on rational decision making and if the revenue is not able to meet the cost of production then the firm should shut down.

In this case what we are saying is that the firm should shut down when the total revenue is less than the total cost or TR is less than TC . So, if you divide both sides by Q we will get $TR \text{ by } Q$ is less than $TC \text{ by } Q$. Now, $TR \text{ by } Q$ this term is equal to price.

Price, because we have seen that the total revenue is equal to P into Q and so, $TR \text{ by } Q$ is equal to P into Q by Q is equal to P . So, what we are seeing here is that P is less than $TC \text{ by } Q$ and $TC \text{ by } Q$ is the average total cost. So, a firm should shut down.

When P is less than ATC that is price is less than ATC then the firm should shut down. And, if the price is greater than ATC then in the long term a firm should enter the market. Now, remember that in the case of a competitive market we had said that there is a free entry and exit and what we are saying here is that if the price is less than the average total cost of production.

Then the firm should shut its operations and it should move out of the market. But, if the price is greater than the average total cost of production, then a firm should enter into the market and start production. So, this is in the long run.

What we are saying is if we do the supply curve in the long run we will see that this is the average total cost and we saw that the average total cost decreases then it increases. So, the average total cost and the marginal cost curve will cut the ATC at this point, the point of the minima, which is what we have observed before.

Now, above the ATC the MC curve or the marginal cost curve becomes the supply curve because the supply curve is given by the cost of producing things and so, above this price this is the supply curve. But, below this price the firm will not supply according to the marginal cost, but the firm will shut its operations and supply zero quantity.

So, when the price is this or the price is this or the price is this the firm should produce zero quantity of goods: it should not be producing at all. But, once the price has increased above the minima of the ATC , then this curve which is the MC curve, the marginal cost curve, becomes the supply curve. Now, this is in the long run.

In the short-run, the firm will have a different profitability. Now, this is because the firm will ask the question that if the total cost is not being met, are we at least able to meet the variable cost, the cost of maintenance of the firm? Now, that is the variable cost.

In the short run what we say is that the firm should continue its operations and the short run till this point where the average variable cost is less than the price which means that it is at least able to meet the cost of running. Because, there is always a sunk cost in all the operations.

A sunk cost is a cost that has already been committed and cannot be recovered which means that if there is a hotel, then there is the cost of land, there is the cost of construction and if you shut the operations you will not be able to recover this cost. So, this is already money that has been put inside.

Now, if we forget this money, if we forget that we had put so much of investment, what is now the cost of at least running the operation is what the firm is interested in knowing in the short run. So, in the short run the firm should shut down.

If the revenue is not even able to meet the variable cost of running which is like the variable cost of paying the wages of those workers that are involved in cleaning of the premises or making and serving the food. Now, in the off-season in the off-tourism season.

We should have at least that much amount of profitability that we should be able to meet the cost of these people, the variable cost of the firm. So, in the short run the firm should shut down if the revenue is not even able to meet the variable cost of running which means that the total revenue is less than the variable cost.

Now, if TR is less than VC , then dividing both sides by Q we will get PR by Q which is equal to P is less than VC by Q which is the average variable cost. So, the firm should shut operations

when the price is less than the average variable cost.

And, so, in the short run the supply curve will look like this. So, if this is the average total cost, if this is the average variable cost, then above this point above the minimum of the AVC we should have the MC or the marginal cost which gives the supply curve.

But, below the average variable cost, the firm should shut operations. So, if P is less than average variable cost there should be no supply at all, the firm should completely shut down. If the P is greater than the average variable cost, then in the short run the firm should be supplying things.

But only in the short run. In the long run the firm should only be supplying if the price is greater than the average total cost. Now, in this context we can look at the profit and loss of the firms. Now, if this is the average total cost curve, if this is the price and this is the marginal cost.

Now, why is that so? We had observed that in the long run this is the supply curve of one firm. It says that if the price is less than the ATC then the firm should shut operations, but if the price is more than the ATC then this is the supply curve.

If the price is greater than ATC, then one firm will enter into the market. Now, in the case of a competitive market where the firms have a free entry and exit, we will have the situation that whenever the price is greater than ATC there will be some firm that will get inside.

Whereas, when the price is less than ATC, then there will be some firm that will be going down. In essence the long term market supply curve will be given by this price curve. At this price any amount of any quantity of things can be bought or sold.

Because of the free entry and exit there will be at least some firms who will be supplying the goods at this price. In the long run, the market supply becomes a straight line. At this price any quantity of goods can be bought or sold because the firms are entering and exiting from the market.

Now, the question arises at this price point the profit of the firm is 0 because the profit is given by this one; the profit is given by P minus ATC into Q. Now, in this case when P is equal to ATC, then you have P minus ATC is equal to 0.

So, 0 into Q is also equal to 0. So, the firm is not earning any profit, but still it is supplying. Now, why would we have such a situation? The answer is, because the profit is given by total revenue minus total cost and total cost also includes the opportunity cost.

Now, this is why we make a distinction between accounting profit and economic profit. Now, accounting profit is given as total revenue minus the explicit cost which is the cost for which a firm is outlying money that is the cost of say land, the cost of the inputs, the raw materials, the cost of wages and so on.

Whereas, when we talk about the economic profit we talk about total revenue minus total cost and total cost is explicit cost and the implicit cost. Now, the implicit cost is those costs for which the firm is not making an outlay of money things such as opportunity cost.

For instance, there is a person who is setting up a firm at an opportunity cost of say 1 lakh rupees because if this person was not running this firm, he would be earning a profit earning an income of 1 lakh of rupees from some other source, probably he was working somewhere and he left his job to set up this firm.

Now, when we talk about the economic profit, we include this 1 lakh of rupees which is the op-

portunity cost of running this curve. So, what we are saying here is that the economic profit is the total revenue minus total cost.

And because total cost is equal to the explicit cost plus the implicit cost. Now, in this case the implicit cost is rupees 1 lakh. Now, because we are subtracting that from the total revenue and when we say that the firm will go on supplying till the economic profit is 0 rupees.

It means that 0 is equal to TR minus EC minus IC which means that IC is equal to TR minus EC. So, we have an implicit cost of 1 lakh of rupees which is given by TR minus EC. Now, because TR minus EC is a positive value, it is 1 lakhs of rupees it means that TR is greater than the explicit cost.

What we are saying here is that because this is a positive value of 1 lakh, it means that TR is very much greater than the explicit cost. The total revenue is very much greater than the amount of money that has to be outlaid by the firm for running of things.

So, when we say that the firm continues to produce at a profit of 0 rupees, it is not the accounting profit we are talking about the economic profit and in this case the TR or the total revenue minus the explicit cost it is still giving the person 1 lakh of rupees of the implicit cost.

Which means that, if the person left this firm, if the person shut down his operations and if he went back to his original job, then he would be earning 1 lakh of rupees. But, when he is running this firm and not earning 1 lakh of rupees from there he is still earning that 1 lakh of rupees from his new firm.

Which means that, when we talk about an economic profit of 0 rupees, it is still giving the person at least that amount of money in profit that he would have earned otherwise. So, the person is still having a substantial sum of money as income.

It is not the income from the wages that he was earning in his previous occupation, but this is the profit that he is earning and which is why the firms are able to work at a profit of 0 rupees. So, in this lecture we had a look at how profit is computed and how firms maximize the profit and continue to maintain profitability both in the long run and the short run. And, because the running of the firm is also related to quite a number of problems of conservation, so, it is important for us to understand what keeps a firm running.

That is all for today. Thank you for your attention. Jai Hind!

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Module 9
Industrial organisation and Conservation
Lecture 3
Monopoly

Namaste! We carry forward our discussion on industrial organization and conservation and in this lecture we shall explore Monopoly. A monopoly is defined as a firm that is the sole seller of a product without any close substitutes. So, this is a firm that is the sole seller.

It means that it is the only seller, only seller of a product without any close substitutes. Now, what does that mean? When we look at things such as rice, now in the case of rice you have different varieties that are available. And if there is a seller who is the only seller of a particular variety.

In that case we will not call that seller to be a monopolist because the variety can be replaced or substituted by certain other varieties usually. However, if there is a variety of price that is the only rice that can be used for say a religious function.

In that case if this rice variety cannot be substituted by any other variety then the person who is the sole seller would be called a monopolist because in that case that would be the only person who would be selling that particular variety of rice. Now, this becomes important because we have observed that yeah in the case of a competitive market.

Everybody is a price taker, but in the case of a monopoly because this is the only person who can provide this particular variety of rice. So, he can charge as much as he wants. So, in this case in the case of a monopoly the monopolist is not a price taker, he is a price maker that is he decides what will be the price of the produce. And because he is the only seller, whatever price he wishes to charge he is in a powerful position to charge that price.

A monopoly is a firm that is the sole seller of a product without any close substitutes. Examples include a firm that is selling a patented medicine. Now, if there is a firm that has developed a medicine for a certain disease, and suppose that is the most effective medicine, that is the medicine that everybody wants to have, so that they can be cured of the disease.

In that case because the firm holds a patent on this medicine it would mean that the firm would be the only seller of the medicine for at least 20 years. In this period of 20 years we will say that this firm will be a monopoly because this firm is the only seller of something that is so unique that it has no alternatives. An example is the owner of the only well in a village.

This owner can charge any amount of money that he wants. Other good examples include things like patents and copyrights. So, when we talk about a copyright, the author who is holding the

copyright is the only provider of that particular book or if the publisher holds the copyright the publisher is the only provider or the only seller of that particular book.

If it is a book that everybody wants to read, say a new installment in the Harry Potter series. Now, this is something that all the fans of Harry Potter would like to read. Now, if they do not get this book they cannot read any other book and say that that book becomes a part of the Harry Potter series.

Because this book by the same author in the Harry Potter series it cannot be substituted by any other book. And in this case we will say that the author or the publisher will be a monopoly because they will be the sole sellers of a product without any close substitutes.

Now, the question is why do we have monopolies? Well, we have monopolies because of 3 main reasons: one is monopoly resources. A key resource that is required for the production is owned by a single firm. In that case we will say that we have a monopoly because of a monopoly over the resources.

And a good example is, say, mine. Say, when we talk about the diamond mines, the De Beers company holds the largest share greater than 80 percent in the whole world because they own the mines they are operating the mines from which the largest chunk of diamonds comes out.

And so, in this case the De Beers firm will be a monopoly because they are the sole sellers, they are the sole suppliers of diamonds because they own these resources. They have a monopoly over the resources. Similarly, for things such as tanzanites.

Now, tanzanites are mined from very few mines and so, the owner of this particular mine can become the sole supplier of tanzanite. So, we can have monopolies because of a monopoly over resources.

In certain other cases we can have monopolies because of a government regulation. In this case the government grants the exclusive rights to produce and sell something and examples include copyrights and patents. Now, why does the government grant exclusive rights to anybody?

In the olden days what used to happen was that if the king had a close friend then to favor his or his friend the king used to grant a monopoly over a certain trade. So, we can have monopolies as a way of favoritism, but these days we have monopolies because monopolies can provide a social good and a social well being.

Now, this is because a number of things such as inventions are extremely time consuming, resource intensive and effort influencing. And so, whenever somebody makes a new product, if the market was made open for all the competition then what would happen is that other people would just copy that product.

Now, making the product for the first time requires the greatest amount of inputs, the greatest amount of effort, but copying the product might not require that much amount of input. And so, if the market was let open for everybody then we would have a situation where nobody would want to make any new products.

Because there is no financial incentive and as we have seen incentives are very important tools to make people do something because people respond to incentives. So, if the government wants that we should have a society in which new things are coming up in which we are able to manufacture new technologies.

New technologies are important because they overall increase the efficiency and reduce the cost because of which the welfare of the whole society would increase. Now, to incentivize people to make these new technologies the government grants them exclusive rights over whatever they make.

Typically the government grants them patents through which they will have an exclusive right on selling that product for the next 20 years. Similarly, when we talk about books or means of art then we have copyrights. Now, copyrights ensure that the people who are doing this creative work in the form of writing a book.

Making a movie or say singing a song these people retain the rights of selling these creations. So, there is an incentive to make these creative things. And so, we can have a government regulation through which exclusive right to produce and sell a certain product is granted to somebody and when we have such a situation we will have a monopoly. And a third reason is that of the natural monopolies. In the case of natural monopolies the cost of production for a single firm is much lesser than the cost of production for competitive firms.

What happens in the case of natural monopolies is that in the case of certain sectors it so happens that if one person provides or if one firm provides the services they would incur a certain cost, but if you have a competitive situation where multiple firms supply the same goods the cost increases. A good example is that of water pipes.

If we have a town and there is a company that is supplying water from a river then this company will have to make a pipeline probably have distribution pipelines that will provide water to the whole of the society and then they can also have the smaller pipelines

The cost of laying the pipelines is very high and so, when this pipeline system has been made then the residents would have to pay a certain price for this water. Now, the price that they will be paying to the firm will be used to recuperate the cost of dig of earth moving, laying of these pipes and providing water

Suppose the per capita cost is coming to be say rupees 10 per liter. Now, this is when one firm is supplied. Now, suppose there is another firm that also comes up and says ok we are also going to supply. Now, what will happen? Now, the second firm that will also have to lay this a very similar pipeline probably next to it because it is supplying to the same locality. And so, it will have to do all this to work and provide for all these smaller pipes as well.

What is happening in this case is that the cost of laying the pipe has now doubled because while one pipe would have provided water now we have two pipes for each of the areas. But, what happens also is that now the water that is being supplied by any one firm is reduced because half of the customers are now being supplied by firm A and half of the customers are now being supplied by firm B.

In that case because of a reduced market share they will each of these firms will not be getting that high an amount because the quantity has gone down. What will they do? They have to recuperate the cost of the earth work and digging of the pipes. So, probably when this second firm comes up then both of the firms start to charge 15 rupees a litre.

So, what we are observing here is that when we have two firms that are supplying the same thing then even though there is a situation of competition, what is happening is that the cost for every

person has gone up. So, now people have to pay more money to get the same amount of water and this is a situation of a natural monopoly.

Natural monopolies arise when the cost of production for a single firm is much lesser than the cost of production for the competitive firms because the more the number of firms that are there the more is the amount of input that they have to put in. Another example is laying off roads.

If we have two roads that are running right next to each other in that case the efficiency of operation will go down or things such as electricity lines or things like railway lines. Now, a large number of these services are natural monopolies, which means that if there is a single firm then the products will be made available at a much cheaper price to the people or to the public as compared to when we have more than one firm.

What we observe here is that the economies of scale that result because a single firm is acting that also results in a natural monopoly. So, what we are observing here is that on the y axis we have the cost, on the x axis we have the quantity and here we are plotting the average total cost. If a lesser quantity of the thing is sold, say in that case with a lesser quantity the cost increases. So, everybody will have to pay a larger cost. Whereas, if the quantity that is being supplied is large in that case people will have to pay lesser costs.

Now, when we have a situation like this, when there is more quantity that is supplied the average total cost reduces, which means that when more and more of the quantity of the goods is being supplied then the firms are able to supply at a lesser cost. Then such sectors become natural monopolies because when we have a lesser quantity of goods that are being supplied because there are more sellers.

What we are observing here is that at this point there are more sellers and at this point there is a single seller because of which a larger quantity can be provided by the single seller. So, the single seller is much more efficient and so, the economies of scale normally result in natural monopolies.

Now, a monopolist market is very different from a competitive market. Because in a competitive market everybody is a price speaker, which means that the price is fixed by the market. And in the case of a competitive market at the set price the firm can sell as much as it wants.

Because there are so many buyers that the firm can sell as much as it wants, but it cannot change the price. The price has been determined by the market. So, in this case the demand curve that the competitive firm faces is a straight line that is at the price that is fixed by the market it can supply any quantity. So, this is the demand curve that the competitive firm faces because it is a price taker.

In the case of a monopoly the demand curve is the market's demand because there is no fixed price. So, what happens is that in the case of the demand curve we have observed that as the price increases the quantity demanded reduces. Now, when this is the demand curve for the market then the monopolist can pick any price.

And so, if the monopolist says that I am going to sell my product at this price then in that case this is the quantity that the monopolist will be able to supply to the market. If the monopolist says that no, I will sell my products at this price. So, at that price this is the quantity that will be sold by the firm

In the case of a monopolist firm, the firm decides the prices and at those prices the demand curve of the market will tell how much is the quantity that will be or that should be made by the firm. Because that is the quantity that is being demanded at that particular price point and so that will be the quantity that will be supplied to the market.

There is this major difference between a competitive firm's demand curve which is a straight line that is parallel to the x axis and a monopolist firms demand curve that is actually facing downwards. Now, we have observed that or we have assumed that in economics people are relational decision makers.

When the monopoly firm is providing this good, it is providing this good to earn a profit to increase its welfare. Now, the question is if it supplies the goods at a higher price lesser quantity is sold and if it supplies at a lower price then higher quantity is sold, but then the amount of revenue that it will earn will be given by the price at which the goods are being sold multiplied by the quantity of the good that is sold.

When the firm is trying to maximize its profit it would also want to maximize the revenue or probably go for an optimum level of revenue. But, what we are observing here is that if price increases then the quantity decreases and if the price decreases then the quantity increases.

In such a scenario how should the monopolist firm decide how much of the price should be kept and how much of the quantity should be produced for the market? So, that is a question that the monopolist firm faces. And the monopolist firm is free to make the prices, it is free to decide the prices.

But because of the market's demand curve the revenue that it earns it will depend on its choice, but it will not have a complete control. Because when it increases the price the quantity that will be supplied to the market will also go down. So, let us now understand how the monopolist firm maximizes its profit.

So, we are taking the example of a monopolist who is holding the only well in a village and everybody in the village has to come to this well to get water. Now, if the price is less, then people would demand more and this is because people will use water for say recreational activities or they will not be using water that stringently, but if the price of water increases then people will try to cut down on the amount of water that they will consume.

Probably people will go for a shorter bath or probably people will shift to crops that do not require that much amount of water or probably people will stop watering the plants. So, this is a scenario in which we will have a market demand curve that will be sloping downwards, but then we also have this monopolist who holds access or ownership of the only well and so, he can decide the prices.

Let us say that the monopolist has decided these prices. So, it can be as high as 11 or as low as 3. And what is the quantity that is being sold in the market when this price has been decided? So, the quantity that has been sold is given here. So, in this case what we are observing is that when the price is less when the price is 3 rupees per liter then 8 liters of water are being sold.

Let us assume that this quantity is given on a per hour basis, that is if the price is 3 rupees then 8 liters of water are being sold per hour. Now, if the monopolist increases the price, so, from 3 if he increases it to 4 then a lesser quantity of water is getting sold. When he increases it to 5, 6, 7,

8, 9, then we are observing that progressively less quantity of water is getting sold. Now, this is because of the market demand curve.

In the case of a monopolist the monopoly firm faces the market demand curve as the demand curve according to which it will have to supply because the price is not fixed. So, when the monopolist is increasing the price, a lesser quantity of water is getting sold. Now, the total revenue TR is given as P into Q . So, when the price is 11 then the revenue is 11 into 0 is 0 rupees. When the price is 10 rupees only 1 liter is being sold. 10 into 1 is 10 rupees is the total revenue.

When the price is 9 rupees then 9 into two is 18 and so on. So, this column is telling us the total revenue. Now, from the total revenue we can compute the average revenue and average revenue is given as average revenue is total revenue divided by the quantity sold. So, at this price point of 10 rupees the total revenue is 10 divided by Q which is 1 and you get 10.

At this price point of 9 rupees the total revenue is 18, 18 divided by 2 is 9. Here 24 divided by 3 is 8. So, what we are observing here is that the average revenue in this case is what is the price So, average revenue and price are the same. What about the marginal revenue?

Now, the marginal revenue is given by change in our total revenue divided by change in the quantity that is when this monopolist is moving from 0 to 1 then the change is 0 to 10

So, in this case the marginal revenue will be given as the change in the total revenue which is 10 minus 0 is 10 divided by the change in the quantity which is 1 minus 0 is 1 or the marginal revenue will be 10 rupees. The when the price is 9 rupees, so, when the price has decreased from 10 to 9 rupees the quantity has increased from 1 to 2 and the total revenue has increased from 10 to 18

In this case the marginal revenue will be given by ΔTR is 18 minus 10 is 8. So, here we have 8 divided by ΔQ which is 2 minus 1 is 1. So, 8 by 1 is 8. So, this is how we compute the marginal revenue. Now, this marginal revenue is for a change from 0 to 1 or a change from 1 to 2 and so on.

When the seller is trying to increase the price or when the seller is trying to change the quantity that is being supplied then we are observing that there is a change in the total revenue and the total revenue it increases reaches to a maximum and then starts to decrease.

So, it has increased from 0 to 30. There is an increase, but then it decreases from 30 to 20 4 and so on. Now, this is because when we write TR is equal to P into Q then there are two impacts that are happening. One is the output effect. So, if Q increases then TR increases, but then there is also the price effect because when Q increases P decreases and when P decreases then TR also decreases.

Because of the output effect the TR is increasing because of the price effect that TR is decreasing when Q is getting increased and which is what we are observing here. When the quantity increases then we can have a situation where the PR may go down or it may go up or it may go down.

If we plot the average revenue and the marginal revenue. So, in this case this is the average revenue and the average revenue is actually equal to the price and so, we can plot that it is going like this. So, it is going like this. This is the average revenue, but the marginal revenue.

Now, remember that this value of 10 is for a change between 0 to 1. So, when we are talking

about the value of 0, the marginal revenue will be a bit greater than 10. So, what we do is we plot it from the same beginning. So, we plot it from a point of 11 and here we are observing that between 0 to 1 that is at a point of 0.5, we have a marginal revenue of 10.

At a point of 0.5 we have a marginal revenue of 10. At a point of between 1 and 2 that is 1.5, it has become 8. So, at this point at this point the value is 8 and so on. So, what we are observing here is that the marginal revenue is less than the average revenue.

This is marginal revenue in the red line and this is the average revenue in the blue line. And what we have observed is that the average revenue is given by the price or it is also given by the demand curve.

But what we are observing here is that the marginal revenue is always less than the average revenue. Now, why is that so? When the firm tries to increase the output by a certain amount then the price goes down because we have a demand curve in this market. This is the demand curve that the firm is facing.

When it increases the quantity the price goes down. Now, when the price goes down it does not go down for only the next item the price goes down for all the preceding items as well because the firm can set up a price, but when it sets up a price. So, let us say that the firm has set a price to be this.

So, in this case this quantity is being sold, but then all of this quantity will be sold at this price. So, when that happens with each increasing amount of goods that is being sold in the market the price of everything goes down and so, the marginal revenue has to be less than the average revenue.

Because whenever we have an increase in the quantity that is being sold the price reduces by so much that the price of everything goes down. And So, the marginal revenue has to be less than the average revenue, which is what we are observing here. So, the marginal revenue is less than average revenue, but average revenue is equal to the demand or the price.

When that happens how does the firm maximize its profits? Now, we have observed before that the quantity to be supplied in the market is given by the point of crossing of these two curves; the marginal cost and the marginal revenue because if the firm is supplying anything to the left of this point.

This is our point of intersection which gives us a quantity Q , which is the optimum quantity. If the firm decides that we should supply a quantity that is less than this, that is we should supply only this much of quantity. Now, in that case we have a situation where the marginal revenue is greater than the marginal cost.

When the marginal revenue is greater than the marginal cost, it means that for every item that is being sold from this point onwards we will have more revenue and less will be the cost of manufacturing this item which means that if the firm produces a single more item then it will only add to its profits because at any stage to the left of our equilibrium point we have a situation where the marginal revenue is greater than the marginal cost.

And so, for every item that is being sold we have a marginal profit and because of this marginal profit the company will decide to sell a bit more. Because remember that we have begun with an assumption that the monopolist is also a rational thinker. So, because the monopolist is getting

some more profit, it would say why not and.

For any point that is to the left of this point of equilibrium because this situation holds true that the feeling of one more item will lead to a marginal profit then the firm will try to move towards the right that is towards this equilibrium. But what happens after it has crossed the equilibrium point? So, let us take a point to the right. Let us take this point.

At this point the firm finds out that the marginal cost of producing is greater than the marginal revenue, which means that for the item that we have just sold we were requiring more inputs or more money to make that item, but we were getting lesser returns.

Which means that we were at a net loss, a net marginal loss, which also means that the firm would think that ok, probably we have manufactured a bit two more because if we did not manufacture this item because the marginal cost is greater than the marginal revenue, if we did not manufacture this item we would have reduced our losses.

And so, for any point to the right of this equilibrium point the firm will try to move towards the left. And so, to a point to the left it moves towards the equilibrium any point to the right it moves towards the equilibrium and so, this is the point that has to be the equilibrium point.

This is the point at which the firm will be earning the maximum profit. Now, at this point we are getting the quantity and we also get the price. Now, this price is determined by the point where this vertical line cuts the demand curve. So, this is the point. So, this will give us the price.

This is the situation in the market for a monopoly format and here as well we have a to an average total cost of making the goods and the marginal cost curve will cut the average total cost at the lowest value. So, this is something that we have observed in the case of a competitive firm and this will hold here instead.

The marginal cost curve cuts the average total cost curve at the minimum. So, that holds true here. But, the only difference here is that the point of cutting off the marginal revenue and the marginal cost will only give the quantity, it will not give the price. The price will be given by this vertical where it cuts the demand curve that will give us the price.

What we are observing here is that while in the case of a competitive firm we were observing that P is equal to MR is equal to MC . So, the price was fixed and this price was the marginal revenue because for each item it will be sold at this price only. So, P is equal to MR and the maximization of profit happened, where MR is equal to MC that is marginal revenue is equal to marginal cost and where it was cutting we were getting the price. So, that was the maximization of the profit, but the price was fixed.

This only gives us the quantity. In this case also we have MR is equal to MC which is giving us the quantity. But what we are observing here is that this MR curve is lower than the demand curve, the demand curve is always upper and so, we will have a price that will be always greater than this point.

So, P is greater than the marginal revenue and the marginal cost at the point of profit maximization. This point P is greater than this point where MR is equal to MC . So, this is the situation for a monopolist firm. This is the situation of the maximum profit.

In such a situation we can compute the profit. Profit is total revenue minus total cost, so, TR minus TC . Now, we can divide this whole portion by Q and multiply it by Q . So, that will mean the

same thing because Q and Q will get cancelled out. So, this is what we are writing here, TR by Q minus TC by Q into Q .

Now, total revenue divided by the quantity, total quantity that is Q is equal to the price because we had observed that the total revenue is given by price into the quantity. And so, if you divide both the sides by Q , in that case this Q and this Q will get cancelled out and so, we have P is equal to TR by Q .

Here we have TR by Q is equal to P or the price minus TC by Q . Now, TC by Q is telling us the total cost divided by the quantity sold, which is the average total cost. And remember that here we were drawing this curve the average total cost curve and the marginal cost curve was cutting it at the minimum and here in the equation also we are coming to the same thing.

Profit is equal to price minus the average total cost multiplied by the quantity that is being sold in the market. Now, the firm has an option. It can either choose Q or it can choose the price at which it will be sold. It will be selling the things and that would determine the other object. Now, profit is price minus average total cost into the quantity.

This is what we are marking here in the curve. The price is given by this point which will tell us the quantity where the marginal cost and the margin revenue are the same. So, this is giving us the quantity, drawing the vertical where it cuts the demand curve and gives us the price. So, this is the price.

And the average total cost for this quantity is given by the point where this vertical line is cutting the average total cost curve, which is this point. This is P , this is ATC and so, this length is P minus ATC , this one P minus ATC . This much is the quantity Q . So, this portion of this rectangle is the quantity Q .

And so, the area of this rectangle is given by A is area is P minus ATC which is the height multiplied by Q which is the base or in other words we can say that this area shown in green represents the profit of the monopolist firm

To recap, how did we come to this point? We first of all computed Q which is given by the crossing of the MR and the MC curve. So, this is the point of profit maximization and this will give us the Q .

Now, for this Q we draw a vertical and this vertical will cut the demand curve at the price point of P and it will cut the ATC curve to give the the average total cost for this quantity and so, this side or the height of the rectangle is P minus ATC , this point minus this point. The side of the rectangle is given by Q .

This is the quantity that we have found out by this point and so, the area of this rectangle is the profit of the monopolist firm. Now, this is different from what we were observing in the case of a competitive firm. Now, in the case of a competitive firm, the marginal cost is the same as the price. So, we had observed here that in the case of a competitive firm marginal cost is the same as price.

And because a competitive firm is a price taker, the price is fixed which means that the marginal cost also is fixed. And so, we are drawing it like this that the marginal cost is fixed at the price which is also the competitive price. So, this is P competitive and this is the marginal cost curve.

This is the demand curve of the market and the point where this demand curve cuts the MC

curve. Now, the MC curve is also the supply curve of the firm because we are talking about not the accounting costing, but the economic costing. So, it includes all the opportunity cost.

And we had observed that a firm will be able to supply goods, a competitive firm will be able to supply goods at its marginal cost and so, this is the supply curve. And the point where the supply and the demand are meeting each other this will give us the quantity that is supplied by a competitive firm.

Suppose that for the monopolist curve firm, we also have the same marginal cost. In that case the quantity supplied by the monopolist firm will be given by this point, where the MR and the MC are cutting each other. This gives us the quantity supplied by the monopolist firm.

When we draw the vertical the point where it cuts the demand curve gives us the monopoly price. Now, two things are important here. One is that the quantity that is supplied by the monopolist firm is less than the quantity that is supplied by the competitive firm.

Here it is important to know that the quantity that is being supplied by the competitive firm is the most efficient quantity because that is the quantity at which the surplus of the society is maximized. The second thing to note is that the monopolist firm supplies at a price that is greater than the competitive firm's price.

These are two things that we need to remember that the monopolist will supply a lesser quantity of the good and at a higher price than a competitive one. Now, that would result in deadweight losses because we have observed that when we talk about a competitive firm the point where the demand and the supply curve meet each other that gives the point of maximization of the total surplus.

That is if we talk about these curves, so, this is the marginal revenue, this is the marginal cost. So, marginal cost is the supply curve for a competitive firm, this is the demand curve of the market and this point it gives the efficient quantity and the efficient price which is the equilibrium quantity and the equilibrium price and we call it as efficient because it maximizes the total surplus.

But for the monopoly firm we have a situation that the quantity is given by this point where the marginal revenue is cutting the marginal cost and we get this quantity and the price is given by this point where this vertical cuts the demand curve and so, we get this price.

Now, the situation is if we take any point between the monopoly quantity and the efficient quantity and if we draw a vertical then what happens? For this quantity let us say that this is quantity Q. So, for this quantity we have a situation that it cuts the marginal cost curve at this point and it cuts the demand curve at this point, which means that the cost of providing the goods to the market for the firm is this much.

So, this is the cost and the value that somebody in the market is putting on this is this which means that there is some person who is willing to pay this much amount to this company or to this firm and this amount is greater than the cost of producing the good which would mean that if a transaction happened between this person and this firm we will have a situation that the person will be happy because he or she will be able to have this product at any price between this V and C.

If that is a price that is decided then there is a consumer surplus because this price will be less

than V and there will also be a producer surplus because this price is greater than C. So, both are having a profit, but the thing is this transaction does not happen because the monopolist firm only sells this much quantity, it does not sell this quantity Q.

And so, there is a situation where there is a deadweight loss because there is somebody who is putting a higher value to the product and the firm can manufacture it at a lower cost, but still it is not selling it because it would reduce the total profit for the firm.

In the quest to increase the profit for the firm we are creating a situation where the society is getting hampered and so, this is a deadweight loss. And so, this triangle shown in green represents the amount of deadweight loss that will be there because of the action of the monopolist firm. Because the firm supplies this quantity to maximize its profit and it does not supply the efficient quantity that actually the society or the market demands.

We need to remember that there is a deadweight loss. Now, the next thing is is there something that the monopolist firm can do to reduce the deadweight loss while ensuring that it also earns the maximum profit. Now, this is something that most firms actually are doing. So, let us now understand how that works.

So, now, the firm is trying to reduce the deadweight loss and the firm is trying to reduce this deadweight loss because it wants to sell a bit more. It wants to earn this profit that was being left out because it was not selling that quantity. But it wants to do that in a manner that will not reduce the price of the good.

Because if it produces more quantity the price goes down which will affect all the goods that it is selling. So, it wants to find out a way in which the firm can sell more quantity while not reducing the cost for everything. And this brings us to the topic of price discrimination.

And let us understand price discrimination with an example. Suppose there is a publisher of a book and this publisher is publishing an ebook. Now, in the case of an ebook the cost of publishing is next to 0, but the publisher is not writing the book. There is an author that is doing the writing and the publisher needs to pay a royalty to the author.

And suppose they have decided that the royalty to be paid is 20,00,000 of rupees. Now, when the publisher looks at the market the publisher finds out that there are two markets. The first market is that of the diehard fans of the author. So, these people who have read the earlier books of the author are ready to pay a higher price because there are fans of the author.

And so, here we have 1,00,000 people who are ready to pay as high as 30 rupees to get a copy of this book, but then there are also certain other people in the market who have not read this author or probably who are not fond of this author. So, these people will buy this book if they can get it cheaply, but they will not pay 30 rupees for this book.

So, the publisher has found out that they will be ready to pay say 5 rupees per copy and in this case the number of people is 4,00,000. Now, the publisher has to decide what price it should sell the book at. Now, suppose the publisher decides that ok I should sell it for 30 rupees.

Because 30 rupees is the maximum that it can charge to these people. Now, when that happens, these 1,00,000 people will buy the book at 30 rupees. So, the firm will get a revenue of 30,00,000 of rupees, but none of these 4,00,000 people will buy the book. So, the revenue from this segment of the market is 0 rupees.

The total revenue is 30,00,000 and out of this 30,00,000 the firm will pay 20,00,000 to the author and make a net profit of 10,00,000 rupees. Now, this is one scenario when the publisher is choosing the largest price. If the publisher chose the second price, if the publisher chose a price of 5 rupees.,

Now in the case of a normal monopoly market. What happens is that when the price reduces that is the price for all the goods. So, even these 1,00,000 people who are able and willing to pay 30 rupees will get this book for 5 rupees because that is the price that the publisher has set.

And from these people the revenue will be 5,00,000 rupees and from these people these 4,00,000 people now because they are able and willing to pay 5 rupees. So, they will purchase the book and the publisher will get 20,00,000 of rupees.

So, total is 25,00,000 of the revenue out of which 20,00,000 has to be paid to the author and so, the profit is 5,00,000 rupees. So, what we are observing here is that in the first case when the publisher chose the higher price 30 rupees it was making a profit of 10,00,000 rupees.

In the second case when it chose the lower price looking at the second market segment it made a profit of 5,00,000 rupees. The question now is can the publisher do something to increase the amount of profits that it can make. Now, suppose the publisher chooses to release the book at 30 rupees and when this book is released then all the diehard fans of the author go and purchase this book.

After they have bought this book now at a later point of time the publisher reduces the price and sells it for 5 rupees. Now, what will happen? The people who wanted or who were ready to pay 30 rupees because they were diehard fans they bought the book immediately. So, that market is now saturated and after they have bought the book the publisher sells it for 5 rupees.

If that happens, the publisher would be making 30,00,000 rupees from the first segment and 20,00,000 rupees from the second segment. So, the total revenue becomes 50,00,000 out of which 20,00,000 has to be paid to the author and so, the profit has become now 30,00,000. So, price discrimination or selling the same good at two or more different prices is a strategy that the monopolist can use to maximize its properties.

What is happening in this case is that earlier because here the marginal cost is the same it is 0 rupees. The point where the marginal revenue was cutting this curve gave the monopoly quantity and the point where it was cutting the demand curve it was giving the monopoly price.

When we had this situation this was the profit given by the green rectangle and these people who were putting a higher value, but were able to get the product at this price they were getting a surplus. So, this was the consumer surplus. And these people who were ready to pay a price that was smaller than the monopoly price, but was still greater than the marginal cost they were not getting anything and so, we had a deadweight loss here.

In the case of price discrimination what the publisher is doing is that it is selling a particular quantity at this price another quantity at this price another quantity at this price and so on. So, now what the publisher can do is to have multiple prices.

And when we have multiple prices the profit gets maximized because in the case of a perfect price discrimination we have innumerable number of prices. So, everybody gets the product at the value that they are putting in the product.

When that happens then the consumer surplus for every person is 0 rupees because they are getting the product at the same price that was their value for the product. So, the consumer surplus is 0 rupees, but the profit is maximized because you are selling each product to each person at the maximum possible price that they were willing to take it for.

And so, the profit increases and the deadweight loss becomes 0 because in that case every person, whatever value this person is putting if it is greater than the marginal cost the publisher will sell them. So, this is perfect price discrimination and in this case all the surplus goes to the producer. So, we have a good amount of producer surplus of profit. The consumer surplus is 0, but at least everybody is getting the product.

And examples of price discrimination include things like paperback edition versus library edition. So, when the book is released a number of publishers just released the library edition. So, it will be a hard bound book at a very high price meant for libraries, but all the diehard fans will buy this book. And once they have bought this book then at a later point of time the publisher will release say a lower price paperback edition.

In that case the publisher is able to do a price discrimination it is able to cater to the needs of the diehard fans and also to the needs of those people who put a lower value to this product. Another is economy class versus business class in the case of aeroplanes. In this case the airlines are selling the same product that is the service of transporting people from point A to point B at two different prices or another example is discount coupons.

Those people who can pay less can always cut these discount coupons from newspapers and magazines and bring them to the shop and in that case they will get a discount. But those people who are not ready to cut these discount coupons or collect these discount coupons are probably very busy people or they are very rich people. So, they just do not give a thought about getting a discount.

In that case those people will not collect these discount coupons and when they go to the market they will get the same product at a higher price. So, these are all different examples of price discrimination. Now, because monopolies have a deadweight loss, we have different public policies towards monopolies.

In certain cases the government says that no, monopoly is bad for the society and so, we should have an increased amount of competition and the government makes use of antitrust laws to break down the monopolies. That is one large firm will be broken down into two or more smaller firms so that the amount of competition increases.

Another policy is price control. So, the government might say that no the monopoly is selling the things at too high a price and so, we put a price ceiling that nobody can sell above this price. Or the government may go for a public ownership or nationalization.

In a number of countries things like roads or railways are natural monopolies they are nationalized. The government is the only one who provides for these and another option is doing nothing. Because here again we have observed that markets are a good way of organizing economic activity and certain governments might say that let the market do what they want to do.

Whereas certain other governments might say that the governments can sometimes improve the market outcomes and so, it is our duty to improve the market outcomes and we will do that. The

choice is dependent on the society that we live in.
That is all for today. Thank you for your attention. Jai Hind!

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Module 10
Labour market economics and Conservation
Lecture 1
Markets for factors of production

Namaste! Today, we begin a new module which is Labour Market Economics and Conservation. This module will have 3 lectures; markets for the factors of production, earnings and discrimination, and income inequality and poverty. So, let us begin with the markets for the factors of production.

Now, we are studying topics such as the market for the factors of production or poverty or inequality because they have a very large building with conservation. And in this context, it is important to remember this chart; poverty is closely related to environmental degradation.

This is because if there is poverty in a society, it would mean less per capita resources which in a number of cases would also translate into overpopulation. Now, what we are saying here is that in the case of poverty people have less amount of resources that are available with them; they do not have sufficient money, they do not have sufficient other resources. Now, if the resources are less in a society, then that might result in overpopulation. Now, this might appear a bit too far based, but in a number of societies what we have been observing is that the human populations go through a demographic transition.

What is a demographic transition? In the case of primitive societies or poor societies in today's time, what we observe is that a child when he or she is born, does not have a very good chance of living till adulthood. Why? Because parents are poor. So, the child in a number of cases is malnourished; he or she does not get a sufficient amount of food. Now, because of malnourishment, the child easily falls sick. Now, if the child falls sick, either he or she does not get to see a doctor, because in this society, the per capita resources are so less that the society does not have hospitals, it does not have doctors. Because hospitals and doctors, again they require money to be there in the first place, they are also resources.

When we talk about a dearth of resources, we are not just talking about a dearth of money, but we are also talking about a dearth of these resources; resources such as resources for education, resources for health and so on. So, the child who has fallen sick, does not get to see a doctor and in a very few situations where he or she does get to see the doctor and the doctor prescribes medicines, then probably the parents are unable to pay for it. Now, when you have a situation, where children regularly fall ill because of malnourishment and they regularly are denied hospital care because the hospitals they just do not exist or when they exist, then they are a bit too

pricey for their parents because of which they become unaffordable; what will happen? In a number of situations children will die.

If children die and they die in large numbers, they have a very less life expectancy; in that situation, if the society has to continue, then it will have to compensate at some point. Because if say most of the children have a life expectancy of say 10 to 12 years, in that case the next generation will not have sufficient number of human beings and ultimately, the size of the population will go on decreasing with time. So, to compensate for a very high death rate, societies tend to have a higher birth rate. That is, if each parent finds out that on an average 4 out of 5 children die that would mean that if the parents have 10 children and 8 die, at least 2 will remain. If the parents have 15 children and 12 die, at least 3 will remain.

So, having more children is an insurance that at least a few of the children will reach adulthood. Now, when we have a situation like that, then there is also a good chance of overpopulation, when the society moves towards the phase-II of the demographic transition. Now, what is phase-II of demographic transition? Earlier, we have we begin with a very high birth rate and a high death rate, but then slowly and steadily when the population does get some resources, when it does get the benefits of medical advancements and we are not talking about hi-fi medicines or hi-fi operation theaters; we are talking about things such as clean water, things such as sufficient amount of food.

Once the society starts to get a sufficient amount of food which reduces malnutrition and these diseases or once the society starts to get clean water or a bit of sanitation or even things like soap, then that would drastically bring down the level of infections that we see in the society. Because of that, the death rate would go down. Now, the society that was earlier having a very high birth rate and a very high death rate, now is having a situation where the death rate is going down; but the birth rate does not go down as fast. So, in such a society, you will have a very high birth rate because it started with a high birth rate and we are now having a reducing death rate. So, a high birth rate and a reducing level of death rate would mean that, in total there will be a net growth of population which might even give rise to an overpopulation.

Because these days, we have at least some level of medical advancement, we have at least some facilities that we as a society provide to most of our people. So, government programs ensure that people have access to clean water, and people have access to sanitation. So, in that case, the death rate goes down and there is a chance that there will be more population growth. Now, of course, every society has to go through these transitions or most of the societies go through such transitions; but then what happens is in the third phase, the birth rate starts to go down because now people do have no longer a need to have more and more number of children because they are now more assured that a number of their children will be able to reach to the adulthood.

So, even having 1 or 2 children is good enough and once we have a situation of a reduced birth rate as well, then the population becomes stabilized. But in the intervening period, there is a chance that the population will rise and which is what we are observing here, less per capita resources could lead to overpopulation. There is also another thing that might occur in certain situations. When the per capita resources are less, then in a number of situations people want to have more children, also because these children will provide hands to work in the fields. So, to in-

crease the resources of a family, it is prudent. And remember, that in economics, we always begin with the assumption that people do rational thinking. So, rationally, if they have more children, that would mean that at least their fields will get plowed and at least their fields will be sown with crops, the crops will be taken care of.

It is prudent for the families, just because of a rational thinking to have more children, when they are more poor which is what we are observing here. So, less per capita resources could lead to overpopulation. Now, in the case of overpopulation, there is an extra stress on the land. Why? Because more children does not just mean more hands towards the field, it also means more mouths to feed. So, when you have a society where more children are being born, a society which has a large population, in that case there are a number of mouths to feed, there are a number of bodies to clothe, which means that the level of resources that is required in total will increase.

Now, here still we are having low per capita resources, but the total number of resources that is needed is given by total resources needed is equal to per capita resources. So, this is resources per unit population multiplied by the population size. In this case even though the per capita resource requirement is less, but because the population size is more, which means that the total resources limited are very high. Now, where will these resources come from? Where will we get sufficient food for all these people? Now, remember here that when we are saying sufficient food, it is not sufficient food when we talk about a biological sense.

So, people are not getting sufficient food, they are still malnourished; but they at least need that amount of food that can remove their hunger. So, when we talk about just feeding the people that in total would require a very large amount of food because the population size is large and how are people going to get that large amount of food? Well, by taking out resources from land. So, in that case a number of forests will be cut and they will be converted into farmlands, which is what we are observing here; land and environmental degradation. So, there is a great stress on land and this will lead to land and environmental degradation. Now, this is even more so because there are less resources that are available with people in this society.

If the resources were more, then probably the same amount of agricultural land would have given a higher amount of crops through the application of fertilizers or pesticides or modern machinery. But because the per capita resources are less, it would also mean that the stress becomes even more, because of a less amount of productivity. So, this leads to the land and environmental degradation, where more and more forests are destroyed and they get converted into farmlands and these farmlands are just working on a subsistence level, which means that even when people work on large sized farmlands, they do not still get sufficient output from the land because the productivity is less.

And also, because in a number of cases the forests are there in those lands that were not that much fertile because if the lands were fertile, then people would have actually converted them into farmlands way back. Only the best lands are preferentially converted into agriculture. So, the forests that still remain are there on those lands that are not good enough for agriculture. Even though there is an expansion of agriculture and there is a huge amount of land and environmental degradation, there will be a further loss of productivity. Because these expansions are be-

ing made in those areas that are even more infertile and when we have a loss of productivity that would further accentuate the poverty.

So, this cycle becomes a vicious cycle and it goes on and on and it is important to remember here that poverty is also a part of this cycle and land and environmental degradation are also a part of this cycle. So, poverty is closely, intimately related to environmental degradation, which is why it is important for us as conservation economists to know what causes poverty and how we can solve poverty.

So, to understand poverty, we need to understand the labour market economics. What is labour market economics? What is the labour market? If you will remember, we had talked about the circular flow diagram. Now, the circular flow diagram is a model of the economy in which we have firms and firms are those parts of the economy that produce and sell goods and services and hire and use the factors of production. A good example is an industry that is making things such as a pen. Now, this industry is producing a good and to produce the good, it is hiring labour, it is making use of other factors of production such as land and capital and by using these factors of production, it is churning out pens and it is selling them out in the market. So, that is a firm.

The other component is households, who buy and consume the goods and services, that is the households will purchase this pen and they own and sell the factors of production such as land labour or capital. So, the people who comprise the household, they have their labour to sell and they sell their labour to the firms and so, we have two kinds of markets. We have the market for goods and services that you are very much aware of because in the good market for goods and services, the goods and services are sold by the firms and bought by the households. So, if you go to the market and purchase a pen, then that is a market for the goods and services.

In this market, there is a firm that is selling you the pen, you are purchasing the pen and so, you are paying the firm with money. In this case, the household spends; they are doing their spending and this spending becomes a revenue for the firms. But there is also another market which is the market for the factors of production. In this market, the households sell the land, labour and capital, which means that people in the households will offer their labour. They will offer to work to save wages or they will offer their land on rent or they will offer their capital which is with them, that is the money that is with them for a share of the profit. When a household invests in say a company's shares, then it is investing in this market. Because it is giving the company its money in the form of its capital, in return for a profit from the shares.

In this market, the land, labour and capital are sold by the households and they become the factors of production for the firm and in return, the firms pay wages, rent or profit which becomes the income of the households. Now, in this module, we are concentrating ourselves with this market, the market for the factors of production and we are asking the question that if there is a household and this household is a poor household, what are the factors that determine how much money this household will get in this market. Because this is the market in which the household is earning. So, what determines, what will be the level of wages that is received by this household? What will determine the level of profits that they receive? What will determine the rent that they receive, if they give the firm their land to establish a factory?

That is the question that we are asking because that has got a lot to do with the level of poverty

that is there in this household. So, if the wage rates go up, if people start to earn more, in that case the per capita availability of resources will increase for the household and when that happens, it is possible that the household will no longer remain poor and if the household is no longer poor, then the pressure that they are putting on the land and environment that will go down, which will have important ramifications for things like conservation. We will have less of our forest that will be deforested to convert into farmlands and we will have less number of people who would be willing to go into a forest to cut trees. So, this has very important ramifications. What governs the wages, rent and profit in this particular market?

We begin by defining a few terms. The factors of production; the factors of production are the inputs that are used to produce goods and service; "inputs used to produce goods and services". Now, what are these inputs? These inputs include things like land, labour and capital and when we talk about this market, we are talking about the demand and supply for land, labour and capital, that will determine the prices that are paid to the land owners, workers and the capital owners.

What we are saying here is that just like in the market for goods and services, here as well we have a demand and we have a supply and this demand and supply will determine at its equilibrium, what is the equilibrium price and what is the equilibrium quantity and we are interested in knowing the equilibrium price and the equilibrium quantity. Capital is defined as the equipment and structures used to produce the goods and services. It is equipment such as tools and structures such as a building. If there is a factory that is residing in a building, so this building is the structure and the equipment or the tools that they are using all of these are known as capital. So, capital is the equipment and structures used to produce the goods and services.

And in the market for labour or in the market for the factors of production, what we are saying is that there will be a demand, there will be a supply. And on the Y-axis, here in place of the prices, we have the wages because the price that is paid to the workers is the wages that they get. So, that is there on the Y-axis and on the X-axis, we have the quantity of workers which is telling us the level of employment that we will have or how easy it will be for a person to get a job in this market. So, these two things the demand and supply in the labour market will determine the wages that people get and whether they get the wages at all or not; that is whether or not they will get some sort of an employment through this market or not.

To understand how demand and supply are regulated in the labour market, let us take the example of a firm that is a labour intensive firm, such as a firm that is making samosas. Now, for our study, we will take the firm to be a competitive profit maximizing firm. Now, when we say that the firm is competitive, it means that it is a price taker. So, it does not have a huge amount of market power and the price that has been determined by the market for the product that it is making, that is the samosa is fixed. Let us say that 1 samosa can be sold for 5 rupees in the market. So, competitive means that this firm is a price taker and it is a profit maximizing firm, which means that the decisions in this firm are taken on the basis of rational decision-making processes, that is the firm tries to maximize the profit that it has.

In this chart, the first column we have the number of workers. The firm can have 0 workers, it can have 1, 2, 3, 4, 5, 6 or any number of workers. Now, because the production of samosas re-

quires labour; so, if you have a firm with 0 labourers, then probably the amount of output will also be 0. So, in that case, we are just taking this value of 0 as a theoretical construct, it is not a practical construct because you will not find a samosa making firm that is not employing anybody. So, if the number of labourers is 1, then the output or the number of samosas that are being made in this firm per hour is say 50. Now, when the firm hires more labourers, then the output will increase. But it will not increase in a regular fashion as in it will not double, when you are doubling the labour that is there being employed.

Now, why is that so? Because there are a number of considerations. Labour is not the only factor of production. You also require things like land and capital and perhaps, they will start to show their limitations in a very short period of time. If there is a firm that has a kitchen and this is not a very big sized kitchen. If there is 1 labourer, he is making 50 samosas. If there are 2 labourers then it is possible that there will be a small shortage of space, that is the 2 might start to bump into each other or they may start to chit chat because you have 2 people, so they will naturally start to have some conversation.

When they are having a conversation, then that is a time or that is an effort that is being removed from the process of samosa making and diverted into conversation or it is possible that now the labourers, they are not getting everything right there on the spot and one labourer starts to make the samosa and the second one starts to move things around. So, it is possible that the efficiency may go down, which is what we are observing here. So, with 1 labourer the firm was putting an output of 50 samosas per hour; with 2 labourers it is putting an output of 90 samosas per hour; it is not putting an output of 100. With 3 labourers, the output has increased further; but it has only increased to 120. With 4 labourers, it has increased to 140.

What we are observing here is that the increase is going on, but it is becoming less and less with time or with more and more labourers. Why? Because when you have just 2 labourers, then probably the space is not that big of a shortage than if you have say 5 labourers. So, when you increase from 1 to 2, the space is not a shortage; but when you increase from 5 to 6, probably it has become a bit too overcrowded. So, in such a scenario, the labourers are not able to have sufficient space to make the samosas, which is what we are observing here. And from this, we can compute the marginal product of the labour. Marginal product is the change in the quantity divided by the change in the number of workers. So, when you move from 0 to 1 labourer, there is an increase of 50. So, delta Q in this case is 50, which is 50 minus 0; delta L is 1 minus 0, which is 1.

In this case, the marginal product of labour, MPL is delta Q by delta L which is 50 minus 0 divided by 1 minus 0 is 50 by 1 is 50. When the number of labourers increases from 1 to 2, then the output increases from 50 to 90. So, in that case the MPL is delta Q by delta L is 90 minus 50 divided by 2 minus 1. Because earlier the Q was 90 and now the ah, earlier the Q was 50 and now it is 90. So, delta Q is 90 minus 50 which is 40 delta L is 2 minus 1 is 1. So, this is 40, which is what we are observing here. So, the marginal product of labour in this case is 40.

When the number of labour is increased from 2 to 3, then delta Q in this case is 120 minus 90 is 30. Delta L because we are increasing 1 labour at every point of time, so delta L is 1 in each case. So, essentially for this labourer, the third labourer, the marginal product is 20 is 120 minus

90 which is 30 divided by 1 is 30. For the fourth one, it is 140 minus 120 which is 20 divided by 1 is 20. For the fifth one, it is 150 minus 140 which is 10 divided by 1 is 10. For the sixth one, it reduces even further.

What we are observing here is that the marginal product of labour is going down or in essence, what we are seeing is that when the number of workers is increased, the output per hour increases; but it goes on becoming flatter with more and more workers. This is known as the production function. The output versus the number of workers is the production function. We are observing that the output is increasing, but the rate of increase is decreasing. It is increasing; but earlier the increase is very high when you add 1 labour, but later on it becomes lesser and lesser. The marginal product of labour is the increase in the output in the amount of output from an additional unit of labour; increase in output from additional unit of labour. So, you are adding 1 more labour, what is the increase in the output which is what we calculated here. Now, here we can talk about the law of diminishing marginal product. What does that mean? It is the property whereby, the marginal product of an input declines as the quantity of the input increases, which is what we are observing here.

As the number of labourers increase, the marginal product goes on decreasing. This is the Law of diminishing marginal product. Diminishing means reducing, so it is the law of reducing marginal product with more and more labour, the marginal product of labour goes on decreasing and the reasons include things like crowding, insufficient access to equipment, chit chats and so on. So, probably there is only 1 mixer or probably there is only 1 stove or let us say that there are only 2 stoves and if you have 6 labourers, then not everybody is having an access to the stove at all times. So, you can have the diminishing marginal product because of crowding, physical crowding or insufficient access to equipment or because of chit chats and so on.

If we plot the marginal product, we observe that in the first case, the marginal product was 50, then 40, then 30, then 20. So, it is decreasing with an increase in the number of workers. So, this is showing us the Law of diminishing marginal product.

Next, we can define the value of the marginal product, which is the marginal product of an input times the price of the output. Now, in this case, the firm is interested in maximizing its profit. So, what the firm does is that it is doing a calculation of what is the amount of output that I am going to get with each labour and what is the market value of that output, that is if an additional labour is going to produce say 30 samosas and 1 samosa is will will be sold for 5 rupees. So, the value of the marginal product of the labour is 30 samosas into 5 rupees per samosa is 150 rupees. So, that is the value of the marginal product. The marginal product of an input times the price of the output, which is what we are showing here.

The value of the marginal product of labour is 50 into 5. Now, here we are taking that 1 samosa is 5 rupees because this is a competitive fund. So, it is not able to change the market prices and at the same time there are so many buyers that if it is producing more samosas that is not changing the price of the samosa. So, whether it sells 1 samosa or whether it sells 1000 or 10000, they will be sold for 5 rupees a piece. Now, this again is a theoretical construct, we do not observe such scenarios in the market.

But for the sake of simplicity, we are assuming that the price remains constant. So, the value of

the marginal product of labour is shown in this column. So, if the marginal product of labour is 50, then 50 into 5 is 250. If MPL is 40, then 40 into the price; 40 into 5 is 200; 30 into 5 is 150; 20 into 5 is 100; 10 into 5 is 50 and 5 into 5 is 25. So, this is how we compute the value of the marginal product of labour.

Similar to what we observed in the case of the marginal product, if you plot the value of the marginal product of labour, we will again find a diminishing curve. Now, this is expected because there will be no difference between this curve and this curve; it is just that the first curve, the marginal product, is multiplied by a constant value. In this case, 5 rupees because the firm is a competitive firm and it is a price taker.

Next, we have the wages. Now, we can have the prevailing wage rate and suppose the wage rate is 100 rupees. If we plot 100 rupees as this green line, then the profit maximizing quantity of labour in this case will be given by this point, where both the curves are intersecting each other. Now, why is that so? Well, when the number of workers is increased from 0 to 1, now this first worker is able to produce a good that can be sold for 250 rupees and the wage that has to be given to hire this labour is just 100 rupees.

So, when the number of laborers is increased from 0 to 1, then the additional labour is producing something that has a much greater value of the marginal product than the wage rate, which means that if the company or the firm hires this labour and uses this labour to produce the good; then the company is adding to its profit and we began by saying that this is a profit maximizing firm. Now, when the number of workers increases from 1 to 2, then the second worker that the company hires will produce a good that is worth 200 rupees, more than what the first labour was producing. So, the first labour was producing goods of 250 rupees, the second labour was producing goods of 200 rupees, so totally the goods that are being produced are now 450 rupees worth. But to make this extra good of 200 rupees, the company has to pay 100 rupees. So, this difference is the profit of the company or of the firm.

For the first worker, the profit to the firm is this much; for the second firm, the profit to the firm is this much. For the third worker, he makes goods worth 150 rupees and the company has to pay 100 rupees. So, the profit to the firm is only this much. In the case of the fourth worker, the value of the goods is 100 rupees; but to make those goods, the firm will have to pay 100 rupees of wages to the worker. So, now the company would be in a dilemma because whether it hires this worker or not, there is no change in the profit. But if the company or the firm hires 1 more labourer, then the value of the goods is 50 rupees; but the firm has to pay 100 rupees. So, this is the level of loss to the firm. So, at this point, the firm was at a profit; at this point, the firm is at a loss. So, this becomes the profit maximizing quantity and at this point, the firm may or may not hire the labour.

We can also look at the marginal profit in each case. What is the marginal profit? It is defined as the value of the marginal product of labour minus the wage rate; the prevailing wage rate. So, if we did this computation for the first labour, the value is 250 rupees, the wage is 100 rupees. So, the marginal profit is 150 rupees. That is, if the company hires this labour, then by hiring 1 unit of labour, the company will increase its marginal profit or will increase its profit by 150 rupees. So, that is the marginal profit. For the second labour, the value is 200 rupees, the wage is 100 ru-

pees. So, you can think of it as the value of the product that you are buying from the market and the cost that you have to pay.

In this case the value of the marginal product of labour is the value to the company and we had seen even in the case of the market for goods and services, if I am going to the market to purchase a pen and the value of this pen in my eyes is 30 rupees and the cost or the price at which it is available is 20 rupees. Then, I will buy this pen. But if the value in my eyes is 30 rupees and if it is available for 50 rupees, then I will not buy the pen and this is exactly what we are observing here. If the value of the marginal product of labour is greater than the wage, that is if the value is greater than the price that needs to be paid; then, the company will or the firm will buy this good. In this case, it is the labour and the marginal profit for the second labour is 200 minus 100 is 100. For the third labour, he makes goods worth 150 rupees and the company has to incur a cost of 100 rupees. So, in this case, the marginal profit becomes 150 minus 100 is 50. And we are observing that the marginal profit is reducing with each extra labour because of the Law of diminishing marginal product. For the fourth labour if the company hires him, then the value of the marginal product of labour is 100 rupees, the wage is 100 rupees which means that the company will earn a marginal profit of 0 rupees, which means that before the company hires this labour and after the company hires this labour, there is no change in the profit. And with an extra unit of labour, now the company is incurring a loss because the value of the marginal product is now less than the wage rate, which means that in the case of our pen example the value of this pen is 30 rupees and it is now available for 50 rupees or say 40 rupees. So, if it is available for anything more than its value, then I am not going to purchase it and similarly, in the case of a firm that is there in the market to purchase labour, if the value of the labour is less and the price of that labour is more. In this case, the value is the value of the marginal product of labour and the price is the prevailing wage rate. So, if the value is greater than the price, the company will buy the labour. If the value is less than the price, then the company will not buy the labour of this person. So, as the number of labourers increases to 6, then you have the situation that the value of the marginal product of labour is 25 rupees and the wage rate is 100. So, the marginal profit is now minus 75 rupees.

This is what we are plotting here. The marginal profit versus the number of workers and the profit maximizing quantity is given by this point, where the marginal profit is 0. So, at all the points to the left of this point, we have that there is a positive marginal profit and a positive marginal profit means that by adding one more unit of the labour, the company will add to its profit. And to the right of this point, we have a negative marginal profit, which means that if the firm adds the labour, then it will reduce its profit and we begin with the assumption that this firm is a profit maximizing firm. So, when the marginal profit becomes negative, then the firm will not hire the labour.

So, the demand for the labour will be determined by the value of the marginal product and the value of the marginal product is the marginal product multiplied by the price of the output. So, in this case, the labour demand will depend on the price of the output.

If the price of the output is more, then the demand will increase. Now, suppose in our example, the P in place of 5, suppose it was 10. If we compute P, P is equal to 10; then, the value of the

marginal product of labour in place of 250, it would be 500. Here, it will be 400 because what we are doing is 40 into 10 is 400; 30 into 10 is 300; 200; 100 and 50. So, this is the value of the marginal product of labour.

In the earlier case, we were observing that when the company hires the fourth labour, then the value of the marginal product of labour is equal to the wage rate; but in this case, when the company hires the fourth labour, the value of the marginal product of labour is greater than the wage rate. So, the fourth labour is definitely hired. What about the fifth one? In the case of the fifth labour, the value of the marginal product is equal to the wage rate. So, now, one more labour will be employed by the firm because the price has increased. And because of an increase in price, it reflects in the value of the marginal product of the labour and we have seen that the profit maximizing quantity is where the value of the marginal product of the labour is equal to the wage rate.

If the wage rate remains the same and if the price changes, then this curve, the red curve, will shift upwards which will change the number of labour that will be hired by the firm at the profit maximizing quantity. The labour demand depends on the price of the output; more is the price of the output, more is the demand for the labour and also, on the marginal product. Now, marginal product in turn depends on labour productivity such as including technological changes and it depends on the supply of other factors such as raw materials. Now, what we are observing here is that the marginal product depends on things like labour productivity. Now, in our example if the labour productivity was more, that is the number of samosas per unit per hour, if it increases because the marginal product of labour increases.

What we are saying is that in place of making just 50 samosas, if this labourer was more trained, and suppose he was able to make 70 samosas. Similarly, if this one was able to make say 60 samosas, if the next one was able to make 55 samosas, if the next one was able to make say 50 samosas, if the next one was able to make say 45 samosas; now, in this case if the price remains the same. We are again talking about a price of 5 rupees. Now, what happens to the marginal product of labour and suppose the next one was able to make 40 samosas? Now, in this case the marginal product of labour will be given as for the first one, it is 70 into 5 is 350; for the second one, it is 60 into 5 is 300; for the third one, it is 55 into 5 which is 275; for the next one, it becomes 50 into 5 is 250; for the next one, it becomes 225 and for the next one, it becomes 200.

So, this is the value of the marginal product of labour, if the price has remained the same. So, the price is 5 rupees only, but the marginal productivity of labour has changed. So, we have increased the marginal productivity by providing more training to the labour. Now, in this case, if the wage rate remains the same, then even the sixth labour will be hired because the value of the marginal product of the labour is 200 rupees; whereas, the wage is only 100 rupees. So, what we are observing here is that if you increase the marginal product of the labour or if you increase the price of the output, the value of the marginal product of the labour increases and this would change the demand for the labour. It would determine how much labour is going to be employed and the marginal product can increase by increase in productivity or it can increase by the supply of other factors such as raw materials.

What we are saying here is that if the labour gets trained or the labour gets say a better stove or

the or we increase the supply of other factors such as say the fuel, then the total marginal product for the labour would increase and even if the price remains the same, the value of the marginal product in this case will increase and we have seen that if the value of the marginal product of labour is greater than the wage rate, then the person gets hired. If the value of the marginal product of labour is less than the wage rate, then the person does not get hired in the case of a profit maximizing firm. So, this determines what will be the number of labour that get employed.

So far, we were looking at the demand side, what about the supply side? The supply of labour depends on the number of factors such as the trade-off between work and leisure or the value that is given to leisure. Now, if we have a society in which leisure is given a very high value. So, people put a very high premium on the time they are able to spend in say chit chatting or watching movies or with their family or say wandering around. If this leisure is put at a premium, then people will have less incentive to leave this premium of leisure and go and work. So, it would depend on how much is the premium that we pay to leisure in a society.

In certain societies, we say that work is worship and so, people are more incentivized to work because of the social set up. But in certain other societies, it is possible that there is a social norm of valuing leisure at a very high premium, in which case people will be less inclined to work. It also depends on the social tastes and traditions, whether women prefer to work outside home or not; whether they are permitted to work outside or not by the society, so that will also determine whether or not women are there as a part of the labour supply pool or not. In certain societies, we can have a situation where even teenagers go out to work. In that case, the labour supply will be more. In certain other societies, the teenagers just do not go out to work. So, the labour supply will be reduced.

In certain societies, people put a very high premium on education. So, in that case people even in their early 20s will not be available in the labour supply. So, the social taste, the traditions also determine to a very large extent, the amount of the supply of labour. Then, it also depends on the changes in the alternative opportunities that people have. With the end of the agricultural season, the labour supply to the industries goes up. Why? Because the amount of employment that was available to the agricultural sector dries out, because the agricultural season has ended. So, when that happens, the supply of labour for industries increases and it also depends on immigration and the movement of labour. So, if more people come into a society or in a country say through immigration or through movement inside the country. So, in that case, the labour supply will increase. So, there are a number of things that determine the supply of labour.

And as in the case of the market for goods and services, here again we have an equilibrium in the labour market. So, there is a demand for labour, there is a supply of labour and the point where both of these curves intersect, this point will give us equilibrium. And at equilibrium, we will have the quantity of workers that are demanded. So, this is the quantity of workers that is demanded or supplied which tells us the equilibrium employment in this particular market situation. So, this is the number of workers that will get employment and they will get employment at a range that is at a wage that is given by this equilibrium wage. So, this is the equilibrium wage and the equilibrium employment.

And just as in the market for goods and services, we can have a shift in the labour supply; the

supply may increase, the supply may decrease. For example, in the beginning of the agricultural season, the supply of labour to the industries will decrease. At the end of the agriculture season, the supply of labour to the industries will increase. If we have alternative employment opportunities, then the supply of labour will decrease to firms. So, there are a number of ways in which we can have a shift in the labour supply.

We can also have a shift in the labour demand. So, a good example again talking about the agricultural season. If there is the beginning of the agricultural season, then the demand for labour for working in the agricultural sector will go up. So, the demand increases in this case. At the end of the agricultural season, the demand for labour in the agriculture sector will go down. Now, when there is a shift in the labour supply, a shift in the labour supply is shown by these red curves. If there is an increase in supply, it is shown by this shift to the right; if there is a decrease in supply, it is shown by this shift to the left. Now, if demand remains the same and we have an increased supply. In that case, this is the new equilibrium.

In this equilibrium, with more labourers, they get employment; but the equilibrium wage rate is less. With an increased supply, with no change in the demand, we will have more workers that are employed; but at a lower prevailing wage rate. On the other hand, if there is a decrease in the supply such as in the beginning of the agricultural season, the supply of the labour to the industries decreases. So, in that case, less number of workers will be employed in the industry; but they will get higher wages. Similarly, when there is a shift in the labour demand; so if there is more demand, more demand is shown by the demand curve that is shifting to the right. So, this is an increase in demand, with an increase in demand the equilibrium shifts and this is the new equilibrium, this was the old equilibrium.

Now, with the new equilibrium, the equilibrium quantity of workers has increased. So, more people get employment and at a higher wage rate. On the other hand, if there is a decrease in demand as shown by a shift to the left in the demand curve, so we have this new equilibrium and at this equilibrium, this is the equilibrium quantity and this is the equilibrium wage. So, if the demand decreases, then we will have reduced wages and less number of workers that get employment. A good example is the employment in the agricultural season; in the agricultural sector at the end of the agricultural season. So, we can have a change in or a shift in the labour supply and demand and that will affect the equilibrium and that will affect the number of workers that are employed and also, the prevailing wage rates.

Similar to the market for labour, we have a market for land. When we talk about the factors of production or the market for the factors of production, we have three factors of production; land, labour and capital and similar to the labour market, we also have a land market, we also have a capital market. In the case of the land market, we have a demand for land and we have a supply of land. And both of these curves intersect together and this gives us the equilibrium quantity of land that is supplied to the firms and the equilibrium price at which the land is supplied. Now, in a number of cases, the firms do not buy the land; but they take the land on a rental basis which is a lease.

In most of the situations, we talk about the rental price of land which is how much you need to pay for a fixed piece of land, say per year or per decade. So, in the land market, we have an equi-

librium quantity of land and we have the rental price of land.

Similarly, in the capital market, we have the demand for capital, we have a supply for capital; both these curves intersect at this equilibrium point, which gives us the quantity of capital that is demanded or supplied by the market and the rental price of the capital. Now, in a number of cases, this rental price is the interest rate that the firm is going to pay to get this capital. So, if say a company raises a debenture and in the case of a debenture, if you buy a debenture, then the company will pay you an interest rate. Now, that is telling us the equilibrium price for the capital. Now, if the company has a very huge demand for capital, then probably they will be paying a more price. So, this equilibrium in the market will tell us the quantity of capital and the rental price of the capital.

Just as before the demand will depend on the value of the marginal product of the factor that is in question. That is the value of the marginal product of land or capital. If the value of the marginal product is more, then these factors will be in more demand and probably, the firm will be ready to pay a higher price. If the value of the marginal product is less for any of these factors, then the demand will be less and probably, the company will be ready to pay less. Now, for a competitive and profit maximizing firm, each factor's rental price equals the value of the marginal product of that factor.

We have seen that in the case of labour, the value of the marginal product of labour is equal to the labour's wages. So, the company is going to hire only till this point, where the value of the marginal product of the labour is greater than or equal to the wages or is greater than or equal to the rental price of the factor of production. So, the factors earn the value of their marginal contribution to the production process.

And because these three factors of production, land, labour and capital they are linked together, because all three of them are together needed for production. So, in this case the supply of any one factor can alter the earnings of all the other factors and a good example is an epidemic that reduces the labour supply. So, if there is an epidemic and people are dying or people are sick because of it, they are removed from the labour market. So, in that case, the supply reduces. Now, when the supply reduces, the marginal product of labour rises. Why? Because of the Law of diminishing marginal product.

If you have more labour, then you have less marginal product. Remember that we are talking about the product, the production that is being made by one extra unit of the labour. If there is more labour, then the amount of production that is made by one extra unit is less. So, it means that if you have more labour, then there is less marginal product which means that if you have less labour, then you have more marginal product and if you have more marginal product and everything else remaining the same, that is the price remaining the same, the value of the marginal product will increase and this will increase the wages.

But because of a shortage in the labour supply, the marginal product of the land will decrease. Why will it decrease? Because less labour is able to work the land and, in this case, there will be a decrease in the rent and similarly, the marginal product of capital will decrease because less labour is able to work the capital and so, this will decrease the return on the capital. What we are observing here is that if the value of the marginal product of any factor of production increases, it

increases because of a change in the supply and we are taking the example of an epidemic that reduces the labour that is available.

With less labour available, we have a greater marginal product of labour because of the law of diminishing marginal product and in that case, the value of the marginal product of labour increases, which will increase the wages that the labour will get in the market. But because less labour is available, so the value of marginal product of land or capital, it will decrease because less labour are able to work on the land or the capital and so, the productivity of land or capital will decrease, which will reduce the rent or the returns for the land and capital.

Such an analysis is known as the neoclassical theory of distribution. What are the salient points that we have seen so far? The amount paid to each factor of production is derived from the supply and demand for that factor in the market. So, we have seen before that, there is a demand and there is a supply and both of these together are telling us the amount that is paid to each factor of production which is the rental price or the wages. Demand for a factor depends on its marginal productivity. Because if the marginal productivity is more, then the demand will also increase and in equilibrium, each factor of production earns the value of its marginal contribution to the production.

So, you earn more, if you contribute greatly to the production of something that is valued high; meaning that, if you have a larger productivity and the product that you are working on or the product that you are making has a higher price in the market, then because you are making more of those goods that are priced higher, you will earn more. And the corollary is that a person will earn less, if his or her contribution to the production is less; meaning that the productivity is less or the product that is being produced has a lower value.

So, people who work in the primary or secondary sectors of the economy, that make such products that have a low value in the market will earn less and especially so, if their productivity also is less. This helps us explain why there is poverty in the society and as we have seen poverty has a great ramification for the cause of conservation.

That is all for today. Thank you for your attention. Jai Hind!

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Module 10
Labour market economics and Conservation
Lecture 2
Earnings and discrimination

Namaste! We carry forward our discussion on Labour Market Economics and Conservation and in this lecture we will have a look at Earnings and Discrimination.

Before we begin let us recap what we had observed in the previous lecture. In the last lecture we had a look at the new classical theory of distribution and in that we saw these salient points, the amount paid to each factor of production is derived from the supply and demand for that factor. Which means that, in the case of the labour market the demand for labour and the supply for labour will determine how many people get employed in the market and what is the rate at which they will be paid or the wage rate.

Second the demand for a factor depends on its marginal productivity which means that, if there is a person who is giving out a larger amount of output. So, his or her marginal productivity is higher and in that case the wages that will be offered will also be higher. Third, in equilibrium each factor of production earns the value of its marginal contribution to production which means that, if somebody is contributing greatly to the production of something that is valued high.

In that case the person will be earning more and a good example is people who work in making software that is valued highly and they are putting in the major share of making that software. So, in that case such people will be earning a lot more than those people who are working to make something that is not valued that high or those people who are working to make something that is valued highly, but are putting in a very small or a minuscule contribution to the actual making of that product.

A good example is a person who is working for the security of the premises where the software is being made. So, this person is not putting a very major share of contribution in the making of the software and in that case the wages that are offered to such a person will be much lesser than the wages that are offered to a software engineer who is actually making the software that is valued highly.

And it is currently said that if somebody is putting in a contribution to a production of something that has a lower value or when the contribution to the production is less, then in that case the person will be earning less which ultimately gives rise to poverty.

In the previous lecture we were analyzing what causes poverty because we have seen that poverty is intimately related to conservation. Now this is because if the society is poor then in a

number of cases we have observed that the population size will increase people will have less per capita resources which would mean that their marginal productivity will be less and to feed the large population or to get resources for the large population when the marginal productivity is less the only option would be to expand into the forest areas.

In that case the forest will be indiscriminately cut and converted into agricultural fields, but still because the forests are generally in those areas that do not have a very good fertility. So, the marginal productive productivity will still remain less, the people will still remain poor, but in this case the forest will also be gone which is why it is important to understand that, why poverty arises in the society.

But then apart from the neoclassical theory of distribution there are also a number of other factors that determine how much a person is paid. And in this lecture we will look at some of those factors.

What are the factors that modulate the predictions of neoclassical theory? Now one such modulating factor is the compensating differential. Compensating differential is defined as a difference in wages that arises to offset the non monetary characteristics of different jobs and good examples are night shifts or dangerous jobs.

What we are saying here is that several jobs have certain non monetary characteristics, which is a way of saying that there are certain jobs that do not have a very big difference in the amount of remuneration that they will provide, but they have certain characteristics that differentiate them against each other. So, a good example is a person who is working as a security guard.

Whether this person provides security in the day time or whether he provides the security in the night time the kind of service that he is providing is the same which is security. The amount of input that he would have to make in keeping himself attentive to the details is roughly the same. But still it is easier for people to work in the daytime than in the night time. So, this is a non monetary characteristic of this particular job, whether a person is going to work in the daytime or in the night time.

Now because working at night time is more difficult. So, people are paid more, now in this case they are being compensated for a difference in a non monetary characteristic.

So, the difference is whether they are working in the daytime or in the night time and this non monetary characteristic differential is getting compensated. So, this is a difference in wages that is arising to offset that is we are trying to nullify or we are trying to compensate for the non monetary characteristics of different jobs.

Examples are night shifts that pay more or dangerous jobs that pay more, for example coal mining. A person who is working in a sector to carry load from one place to another place that is a person is working as a porter will be earning less money if he is doing the work of a porter in a market or say in the railway station, but he will get much more amount on much more amount of compensation or wages if he is working say in a coal mine, why?

Because coal mines are generally dirty places to work, they are generally dangerous places to work because at any point of time an accident can happen with a greater probability, than an accident occurring say in a market area.

Because people have to be lured to work even in these difficult surroundings or in these dirty

surroundings. So, they will have to be paid more and this is known as the compensating differential, this is a compensation for the differential characteristics of certain jobs.

Especially, depending on whether they are more difficult or whether they involve working in a dangerous situation or in dirty situations. So, this is known as a compensating differential and this modulates the predictions of the neoclassical theory.

Another difference that modulates is the human capital. Now human capital is the accumulation of investment in people such as education and on the job training it is an accumulation of investment in people that is how much amount of investment has been accumulated in a person by means of things such as education or on-the-job training and a good example is that income increases with education and income increases with training and experience.

What we are observing here is that if we talk about people having the same experience, but different education levels doing the same job. Now if you remember when we were talking about the neoclassical theory of distribution we were saying that the amount paid that at equilibrium each factor of production earns the value of its marginal contribution to the production process. Now in this case what we are observing is that people are doing the same job. So, the neoclassical theory of distribution would say that these people should be paid the same amount.

In actuality what we are observing is that people have paid different amounts. So, a person who is a graduate of the high school is paid less, a person with a certificate or diploma is paid more than the high school graduate, a person with a bachelor's degree is paid even more, a person with a masters degree is paid even more and a person with a PhD is paid even more. Now even though these people are doing the same job and they have the same experience. The only difference is the difference in the education levels.

In this case what we are observing is that we are paying these people more on account of the accumulation of investment in the people by means of education or training. So, this is a modulating factor. Because of this factor the neoclassical theory of distribution does not exactly apply. So, this modulates the results of the neoclassical theory to some extent.

Here again a person who is working in a sector that is making things that are valued very high in the market and is putting in a major contribution will be earning more than a person who is putting in a smaller contribution or a person who is working in a sector whose output is not valued that high.

The neoclassical theory still remains. If we talk about two people who say our software engineers. They will still be paid more than say two people who are working as security guards, but among these two software engineers the one who has got more education will be paid more.

This is a payment that is being made on account of the greater education that this person has. This is a payment on account of the human capital that has been accumulated in this person by means of higher education. So, this is human capital that modulates the results of neoclassical theory.

The question is why should somebody do that? Why should a firm pay more to a person who has a higher amount of human capital accumulated in that person. And there are several reasons, one education and training increase the marginal products of labour and this is true to quite an extent, education and training increase the marginal products of labour.

What we are saying is that if there are two people who are say working as software engineers and one person is just a novice he has just come out of a college. And there is another person who has accumulated a lot of training by working in some other company or he has acquired education by working in an academic institution. So, he has gained a masters degree or a PhD degree.

What happens is that when the person has been working in a particular sector or has gained a higher education in that particular sector, then they are exposed to a lot more challenges, a lot many problems than a person who is a novice who may not have been exposed to those challenges. Now because of these exposures and because of having an ability to solve the problems in those situations in a number of cases people learn how to tackle certain situations.

For instance if there are two software engineers and there is a particular bug that has come up or corrupt into the software then a person who is more experienced either by account of a higher training or by account of say a higher education he will be in a much better position to find out where the bug lies because in his lifetime he has experienced several setbacks in several sorts of course.

Whereas, a novice may not have been exposed to so many problems and so he will have to start from the scratch. So, in this case the marginal productivity of the person with higher education or with higher training will generally be higher. This is the first reason that education and training increase the marginal products of the neighbor and. So, the human capital leads to a higher payment as in the case of the neoclassical theory of distribution.

Another reason is that higher education is the compensating difference for the cost of education both in terms of opportunity cost and time involved. What we are saying here is that the higher income of the people who are educated more is the society's way of compensating them for the troubles that they have taken, troubles in terms of the opportunity cost.

That is if the person with the higher degree had not gone for higher education he or she would have been working somewhere and by working somewhere they would have been earning some amount of compensation, some amount of payment.

To get the higher education they had to forgo this payment. There is an opportunity cost that is involved. A person who is going for a higher degree is not going for the work in the labour market and the society needs to compensate that person for the loss of that opportunity.

The society compensates for the opportunity cost and the society also compensates for the time that is involved because a person who goes for a higher education for a higher degree has to spend a lot of years in an educational institution working on say very theoretical subjects.

This person, by working on these theoretical subjects, will also gain an insight into problem solving. That will increase the marginal productivity later on, but currently when the person is there in an educational institution he or she might feel that there is a huge amount of and there is so much of the time that needs to be invested into higher education.

All this needs to be compensated by society. Later on when the person joins the job market and the higher income to people with higher education is the way of society compensating for this loss of opportunity and putting in so much time which is the cost of education. In this case what we are saying is that because education is difficult. So, society needs to compensate for this difference.

That is similar to the case of a person who was working a night shift or who was working in a dangerous profession. They need to be paid more because there is a level of difficulty involved there is a level of danger involved.

Similarly a person who has put up so much of the cost into education in terms of opportunity cost and time will also have to be compensated for because higher education typically is difficult and the third reason is that education and training are signals for higher ability.

What is a signal? Signaling is defined as an action taken by an informed party to reveal private information to an uninformed partner signaling is an action taken by an informed party, which means that when we talk about a person who was getting into an employer relationship with an employee.

Suppose I am the owner of a firm and I need to check who is the best person for the job. Now I do not know how good person A is or how good person B is. Now they are having this private information that probably person A knows that he is an extremely lazy person, but in the interview person A will not tell me that sir I am a lazy person. Probably person two is completely disregardful of punctuality. So, it is possible that person when I hire him then probably person two will never come to the office on time because he is completely non punctual.

But then person two will not come to the interview and say that I am a person who pays no punctuality. Both these people when they come for the interview to get the job they will be projecting themselves as the best person for the job. So, both of them would say sir I am a very hardworking person and I am a very punctual person. Now the employer when he needs to know which person to hire, how is he to extract this private information?

Because nobody is going to tell the employer that these are my limitations, we have a situation where there are certain people who have this private information about their abilities and about their disabilities and there is another person who is the employer, who needs to extract this private information out of these people.

Herein comes signaling. It is an action taken by an informed party to reveal the private information to an uninformed party. So, what will both of these people do? These people suppose person two says that sir I am having a so and so degree from a second set institution then this is a signal that person two is providing.

In that case the employer finds it much easier to judge whether he should hire person one or person two because the employer would think that ok I have these two people and both of them are saying that they are the best person for the job, but then the first person does not have a higher degree the second person has a higher degree from a very prestigious institution.

It means that person two was able to secure an admission to that prestigious institution and at the same time person two was able to pass with flying colors. I can see his grade sheet. So, I can see if this person is able to put up hard work or not. So, this is a signal now it is very similar to, say, a peacock when it dances. When a peacock dances it splits its feathers for the peahen to see if this peacock is fine or not.

When peacock and peahen are mating in the mating season the peacocks will show off their wings and, if there is a peacock which, say, is a diseased peacock, in that case the disease will show itself in the wing patterns, because a peacock that is a diseased peacock that is not getting

enough resources then in that case probably the feathers will not shine that much. Probably it will have fewer feathers than a peacock that is in the prime of itself.

By showing themselves law the peacocks are giving a signal to the peak end that this is my ability this is my level of health status and similarly in the case of education people can use their education as a signal to tell the prospective employer that these are my abilities.

If I have a degree from such and such institution it means that I am able to put up hard work. It means that I am a punctual person. So, whatever the other person says that is immaterial you can just have a look at my grade sheet and you can make your own choice, so that is signaling. So, education has a very important role in signaling.

Similarly, training because if a person has been hired by say a very prestigious form before. Then the employer will get this idea that if this person could work in this firm then probably this person is a good person. He will be an asset to our organization as well because he has already worked in such a prestigious position.

So this again is a signal. Signaling is an action that is taken by an informed party to reveal private information to an uninformed company. Now there are certain characteristics of good signals; these signals must be costly so that everyone does not get to use them, which means that if you use a signal suppose there are two candidates who have come for a job interview and the first candidate says that sir I am very fond of Jagjit Singh songs, the second candidate says sir I am very much fond of Kishore Kumar songs.

Now in this case whether a person listens to Jagjit Singh or whether he listens to Kishore Kumar that has got little to do with the kind of one that is involved in the form. And at the same time it is very easy to get Jagjit Singh songs or Kishore Kumar's songs because these days everything is available on the internet and people can listen to these songs or watch these songs on radio or television. So, people have easy access to these whereas, for a signal to work properly it should not be. In this case the song that a person hears will not play the role of a signal because the employer would say that how does it matter because to get this signal to listen to say Kishore Kumar songs or Jagjit Singh songs you do not have to enter a very huge amount of cost.

There is no great cost involved. Whereas, in the case of education it is extremely costly both in terms of money for fees, both in terms of opportunity cost that somebody has to give up and also in terms of the time that one has to put in.

So signaling will only work when it is costly so that everyone does not get to use them and education is costly. Secondly, signaling will only work when it is something that should be more costly for the lesser quality product than for the higher quality product which means that if there are two people one listens to Jagjit Singh the other listens to Kishore Kumar then there is no difference between these two people in terms of their abilities.

Whereas, in the case of education if somebody says that I was able to secure this grade at this institution, in that case a person can very easily make out that doing this thing was difficult for a person with lesser ability, but doing this is easier for a person with higher ability. So, passing is easier for a person who is hardworking or who is intelligent or who is diligent, but passing is more difficult for a person who is lazy or unintelligent.

So in this case there is a differential costing involved which means that signaling is cheaper for a

person with a higher quality or with a higher ability, but signaling is costlier for somebody with a lesser ability.

So, education becomes a very good signal because it is easy for somebody who is having the desired qualities, but it is costly or even costlier for a person with lesser abilities. A person who is having a lesser ability in terms of say doing problem solving or in terms of putting up punctuality or working hard.

Now this person will find it extremely difficult to pass a course whereas, a person who is hard working will easily pass the course. In this case there is a difference that exists between a person with a higher quality or ability and a person with a lower quality or ability; this is another characteristic of a good signal. It should be more costly for a less quality person or product than for a higher quality product or person.

Whereas, if you wanted to use listening to a song by Kishore Kumar or Jagjit Singh as a signal, then there is no difference between the cost for a higher quality product or a lower quality product or person.

So a person with a higher ability will also find listening to these songs equally easy or difficult than a person with a lower quality. So, it does not work as a signaling. Signaling should be something that is costly and this cost should be different for people with different abilities and because education is both costly and it has a differential costing for people with higher and lower abilities. So, it acts as a very good signal.

Now if a person has a higher degree from a more prestigious institution then it acts as a very good signal and the employer will make this decision that yes this person is intelligent and this person is hard working and this person is punctual and you can add n number of other differences here. So, signaling modulates the results of the neoclassical theory.

Another thing that modulates the results is the ability, effort, chance and appearance ability. So, higher ability people get higher wages and this ability may be a result of hereditary upbringing, exposure and so on.

What we are saying here, is that suppose you have two people who are working in a job say they are working as porters. Now a working person has a higher ability which means that he can work for longer hours and he can pick up heavier weights. Now this person with the higher ability will at the end of the day earn more than a person with a lower ability. Now this is because the person with the higher ability is able to put up a greater marginal product.

In this case what we are saying is that people with higher ability get higher wages. It is not necessary that this ability stems just from the person, but it may be a result of heredity, upbringing, exposure and so on.

A person who is born to intelligent parents may be intelligent because he got intelligence in heredity. So, even though this person is not putting up that much of an effort, still this person is able to pass easily.

In that case he will be able to get an education with lower effort, but then once he gets this education it will act as a signal in the market or this difference in ability may be because of a difference in upbringing. There could be a case in which the parents have inculcated the tendency in their children to work very hard. In the other case you can have parents who have not inculcated

this ability.

In this case the upbringing would lead to a difference in the ability because at the end of the day the child one when he grows up he will be working very hard as compared to child two because it is there in his upbringing.

From early childhood on he knows that he needs to work hard and. It is now a part of his character, it is a part of his nature. Upbringing can also make things exposure can bring changes in ability. A person who has worked in different sectors or a person who has worked in different countries and is exposed to different sorts of problems will have a higher ability for problem solving than a person who is not exposed to these things.

Exposure may change ability and in the case of ability a person with higher ability will typically get a higher wage even though both of these people are working in the same sector. Effort, a person who is putting up more effort is paid more than a person who is not putting up enough effort. Basically if there are two candidates both have equal abilities, both have equal education, but what happens is that person one works for 12 hours in a day, but person two works for only 2 hours a day the rest of the time it does not work.

In that case because person one is putting up more effort. In that case he will typically earn much more in the market. He will be getting a higher wage than person two. So, the result of the neo-classical theory of distribution is modulated by the effort a person puts in higher effort means more wages. Chance, now this is a very important factor students who are graduating during a recession time will get paid less.

Now, these students may be having the same ability, they may be putting up the same amount of effort than their previous generation of students, that is their seniors, but just because the market is in a recession period.

In that case it may be more difficult to get a job or it is also possible that the job that these people get will be paying them less. Now this is not because of any difference between the students of this class and the students from the previous class.

It is just a luck factor, just a chance factor. People who graduate during times when there is a recession typically get lower wages. A chance factor is also involved, appearance is also involved because good looks may be needed for certain jobs with public exposure.

If you talk about a job such as that of a news anchor. A person who looks better, who has a better appearance may be paid more actors. Now in the case of actors, if they look beautiful, if they look smart they might need a higher payment.

Appearance may play a role especially in those jobs that involve public appearances say in the case of TV or cinema good looks are also a signal of upbringing and an availability. So, they might be needed or they might act as a signal.

Now it is a signal of upbringing and ability. For example, does a person know how to tie a tie or not? In this case it is acting as a signal because if a person knows how to wear a tie properly, if a person knows how to wear a suit properly then probably they have been brought up in an environment where these things were already taught to them.

With these, people can read out certain deductions about the qualities that people might have not because you have an indication of the kind of upbringing this person has been through. So, good

looks might also be a signal. And in certain cases the beauty premium may be just a form of discrimination. So, ability, effort, chance and appearance regulate the wages.

Then we have the superstar phenomenon that regulates wages. People like Lata Mangeshkar or Sachin Tendulkar or Amitabh Bachchan earned way above their colleagues. They are the superstars of society. Lata Mangeshkar earned much more than other singers of the same time who were probably putting up the same amount of effort, but those singers were getting paid less, but Lata Mangeshkar was getting paid more. Sachin Tendulkar got much more income from playing cricket than another person who was probably putting up the same amount of effort. Now, why do we have these people who get way above the average wage rate that is prevailing in the society?

Not all the singers get paid equal to that of Lata Mangeshkar, not all cricketers get paid equal to that of Sachin Tendulkar, not all actors get paid equal to that of Amitabh Bachchan. Now, this is the superstar phenomenon and it happens when every customer in the market wants the goods supplied by the best producer.

So basically, if you have a chance to watch a movie by Amitabh Bachchan or by or watch a movie by an actor who is completely unknown. So, people would generally think that because Amitabh Bachchan is so good at acting. So, let us watch that film. So, people want to have the product of the best producer of that particular good. Lata Mangeshkar is probably the best singer. So, she is the best producer of songs, especially Hindi songs.

Sachin Tendulkar is the best producer of the entertainment or the thrill that you get by watching cricket and most of the people want to have the best and the good that is produced is. If it is possible to provide it to every customer at a low cost it is possible to provide it to every customer at a low cost - so what we are saying here is that suppose the good is something like the work of a doctor. Now in this case a doctor when he is treating one patient will not be treating another patient at the same time and. Depending on the demand and supply in the market the amount that the doctor will charge to the patients will change. If there are very less number of doctors and there is a very great amount of demand then probably the doctor will start charging more.

So, there will be a natural equilibrium in the market and you cannot provide the services of a doctor to everybody at a very low cost, but what happens in the case of professions such as cricket or profession such as acting. Once a movie has been made it can be shown to n number of people for a very low cost.

These days when we watch a movie on a streaming medium it hardly costs anything to watch the movie. So, everybody can now afford to have the services of the person who is the best producer of the good in the base of a doctor not everybody gets a chance to afford the services of the best doctor.

Whereas in this case the good is being produced and distributed in such a manner that everybody can afford to have the good of the best producer.

So everybody can watch Sachin Tendulkar play on the TV screen, everybody can listen to Lata Mangeshkar songs at a very low cost, everybody can watch Amitabh Bachchan act in a movie at a very low cost. And it is only in these professions that we start to observe the superstar phenomenon. So, in the case of the superstar phenomenon you have certain superstars who get paid way

above their colleagues.

Because there are two things: one they are the best producer of the goods that they are producing, and every customer in the market wants to have the goods supplied by the best producer.

And second, the goods are being produced in such a manner and distributed in such a manner that it is possible to provide it to every customer at a low cost. In that case everybody will just flock to the best producers of the good and. The best producers will be earning way above the second best which is not the case say in the case of doctors. The best doctor may not be earning way above the second best or the third best.

But in the cases of superstar phenomenon the people who are the best they earn way above the second best or the third base. That is the superstar phenomenon and this is something that is not explained by the neoclassical theory of distribution.

This is another factor that modulates the wages that people get in the market, if they are working in a sector that permits them to provide the goods at very low cost and when they are the best in the field and they are working in a in a sector where everybody wants to have the goods or services by the best in that case they might be earning way above the crowd that is the superstar phenomenon.

Another modulating factor is the case of above equilibrium wages because of the minimum wage laws. So in this case the government is influencing the wages that people will be getting. The neoclassical theory was saying that people are getting wages that are equal to the value of their marginal product of labour, but the government may tinker with it and the government may say that no this is the minimum that you will have to pay these people.

We have observed that in the case of a non binding price floor. Suppose the government has put up this price floor that this is the minimum wage. In this case the law department is saying that this is the minimum wage that you need to pay. And suppose the market is paying above this minimum wage. So, this is the natural equilibrium in the market then we do not have an impact of the non binding price floor.

But in case the minimum wage which is shown by this red line is more than the natural market equilibrium that is shown by this point. In that case there will be a difference between the quantity that is demanded at this price. Quantity demanded is given by this point where the demand curve is intersecting with the price curve or the price floor curve.

The quantity that is supplied is given by this point where the supply curve is intersecting with the price curve. In that case we will have a quantity demanded that is less and a quantity supplied that is more and we will start to observe a surplus in the market. So, the actions of the government may tinker or modulate the results of the neoclassical theory of distribution.

In these cases we can have a surplus, a situation in which the quantity supplied is greater than the quantity demanded impacts selling is possible only for a few sellers. In this case workers who can appeal to racial familial or other ties what we are saying here is that in the case of minimum wages because there is less demand there is a huge amount of supply.

Not everybody gets paid, not everybody gets work and those people who can appeal to say familial ties or their cultural ties or their linguistic ties they might get employment and other people will not get employment.

Now the neoclassical theory of distribution was saying that every person is getting paid according to the value of their marginal product of labour, but in the case of such government interventions, it is possible that two people who can put up the same value of marginal product of labour one of them gets employed the other one just does not get employed. So, this is a modulation: it may result in losses to sellers due to unsold inventory. In this case the sellers are the workers because they are selling their labour.

So there will be losses: there will be losses for the workers because of their unsold inventory in terms of unemployment. The workers in this case have labour to offer to the market for a price, but because the price has been increased to a level above the market equilibrium.

So, nobody is hiring them. This is a loss to the workers and this may also have a long term impact in terms of closing of industry or job losses because the price is a bit too high for people to pay. So, in that case it will be difficult for people to run their industries or it may be difficult for at least some people in their industries.

And because of that they might close the industries which will create even greater unemployment. So, this is another modulating factor to the neoclassical theory of distribution.

Another example of or another case of above equilibrium wage is union. Unions can do collective bargaining and use strikes to demand above equilibrium wage. In this case the workers will not get paid according to the value of their marginal product of labour, but the neoclassical theory of distribution was same, but in this case what the unions do is that they go for a collective bargaining and they say that if you do not pay as this much amount they will strike.

A union is a worker association that bargains with the employers over wages and working conditions and strikes are the organized withdrawal of labour from the firm by a union.

In this case the union says that if the firm does not pay us or pay the workers at this rate, we will not permit anybody to work. Now this is very similar to the case of the minimum wages that are put in place by the government.

Even in this case the wages that are demanded are above the natural equilibrium of the market and we might also observe that in a number of cases because of these strikes or because of the inability of the firm owners to pay this high a wage they may just close the industry. So, there will be a huge amount of unemployment, but this is also another case that is modulating the results of neoclassical theory.

And third is the use of efficiency wages by firms to raise productivity, retain good workers, reduce turnover or reduce expenses of hiring and training. And in this case the efficiency wage is described as the above equilibrium wages paid by firms to increase the worker productivity.

In this case there is no role of government. The government is not saying that the firm should pay above the market rate, the workers themselves are not saying that the firm should pay us above the market rate, but the firm in its own best interest pays the workers above the market rate.

Now why should firms do that then this is because even when one person is fired and another one is hired, we can achieve the same quality at the same rate, but the process of firing and hiring them are also expensive processes because the firm will have to put up an interview.

It will have to call for applications, it will have to search all these applications, it will have to in-

terview, there will be a decision making that will have to be made and all of these require costs. So, the company might say that ok the people who are working for us and we know that they are working well let us pay them a bonus so that they do not also have an incentive to go to another company. So, they will not leave us and the amount that we would have had to spend to organize an interview, we will pay that amount to these people. So, our headache of hiring a new person is reduced and these people will go on working for us and we know that these are the good people. So, we want them to work for us.

So, the company might pay people or pay its workers above the market equilibrium in the aim to increase the efficiency of people or to retain the employees or to compensate for the alternative which would be to hire another set of workers.

So these are known as efficiency wages above equilibrium wages that are paid by firms to increase worker productivity or to retain good workers to lose turnover or to save the expenses of hiring and training. Now in this case because the firms are taking this decision out of their own free will there will hardly be negative consequences.

We also saw that another way in which the results of the neoclassical theory get modulated is discrimination. Now, discrimination is defined as the offering of different opportunities to similar individuals who differ only by a race ethnic group sex age or other personal characteristics.

When we talk about discrimination we are saying that there are two workers who are practically the same they have the same education they have the same ability, they will put up the same effort, but still we employ one and we do not employ other.

Because the one that we are hiring probably speaks the same tongue or belongs to the same community or the same religion. In this case we will say that we are discriminating one against the other.

It is the offering of different opportunities to similar individuals who differ only by race, ethnic group, sex, age or other personal characteristics. A good example is the gender pay gap, the average difference between the remuneration for men and women who are working.

Even though men and women might be having the same qualifications and the same education they might be putting up the same amount of effort, but in certain societies by tradition the women get paid less. This is the gender pay gap.

In our country the gender pay gap in the year 2007 was 44.8 percent and for the year 2013 was 24.81 percent. So, we are observing that as our society is modernizing the gender pay gap is reducing, but we still have a long way to go. So, this is an example of discrimination.

The market, in certain cases is able to solve the problem of discrimination by itself. Now, how is a free market able to solve this problem? In a competitive market a firm that cares only about profits will make products at a lower cost than firms that do discrimination because the firms that are doing discrimination might at times be hiring workers with lesser abilities or who are putting up lesser effort because they have this criterion of the person belonging to the same community as one of the criteria of hiring the people.

Whereas, another firm who is not discriminating and is looking only for profits this firm will be hiring the best workers. And in that case the firm that is not doing the discrimination end up producing the goods at a lower cost. Which could mean that, in the medium or the long term this

firm that is not doing discrimination that will gain a larger share in the market because they are producing the goods at the lower at the least cost at the lowest cost.

And we have seen before that in the case of a competitive market the firms that produce good quality products at the lowest possible price are the firms that get the orders.

So over time the firms that care only about profits will out compete the firms that practice discrimination and thus a competitive market with free entry and exit can automatically remedy the employee discrimination. Which tells us that the free market has a free entry and a free exit, which means that any firm that is able to produce goods at a cheaper price and at a better quality is able to enter into the market. In that case the firms that are not doing any discrimination, because they are having the best workers they will make cheaper products with good quality, they will out compete those that are making discrimination and in a short while we will see that the market is only occupied by those firms that are not doing any discrimination.

The market is a way of tackling discrimination by the employees which is also why we say that markets are usually a good way to organize economic activity, but the sad part is that this may not always happen because in certain cases we observed discrimination by customers or discrimination by the government. Now if this is the situation then the market will not be able to solve this problem by itself. If customers are willing to pay to maintain the discrimination then free market will not by itself remedy discrimination.

By this what we are saying is that if customers say that we do not care about the quality we do not care about the price we only care about whether this product was made using workers of our own community. So, even though we get products at a higher price with a lower quality, that is ok with us as long as people from our community are getting jobs. Now in such a scenario the free market will not be able to solve the discrimination because people are paying for the discrimination.

In the theoretical context we had said that people are rational decision makers. So, everybody is trying to enhance their welfare by getting the the best quality material at the cheapest cost, but if people do not do this in this this relational decision making in that case the free market will not be able to solve the problem of discrimination.

In certain other cases the discrimination can also be government mandated example apartheid in South Africa. So, in certain cases the government may itself say that only people belonging to such and such communities are going to get employed. Now when discrimination is government mandated, then again the free market will not be able to solve the problem and in such cases legal remedies may be needed to counter such discrimination.

In our country we have a number of such legal provisions especially in our constitution. So article fourteen in our constitution says that the state shall not deny to any person equality before the law or the equal protection of laws within the territory of India. So, our constitution is saying that the every person is equal in the eyes of the law and will get an equal protection of laws article 15 says, the state will not discriminate the state shall not discriminate against citizen on grounds only of religion, race, caste, sex, place of birth or any of them.

The constitution says that nothing in this article shall prevent the state from making any special provision for women and children or for the advancement of any socially and educationally

backward classes of citizens or for the scheduled castes or the scheduled tribes.

The constitution is also saying that there shall be an equality of opportunity for all the citizens in matters related to employment or appointment to any office. The constitution is also saying that no citizen shall get discriminated against because of these factors.

We have the constitution saying provision of reservation then we have options like untouchability being abolished we have things like equal pay for equal work for both men and women.

What we are observing here is that in our country legally because of the constitution we have had several provisions that are aiming to remove or reduce discrimination.

Discrimination by the state is completely removed and in certain cases the societies that were discriminated against historically they have been provided a larger opportunity by means of reservations. And because of these provisions we also had a number of laws that were made: the equal remuneration act, the maternity benefit act, the factories act and we also have affirmative action in the form of reservation, special education and awareness opportunities. So, what the government is doing by all this is that in our country we are trying to remove discrimination

We can also touch upon the principle of economics that governments can sometimes improve the market outcomes because we saw that if the society is doing the discrimination and is paying for the discrimination then the free market will not be able to remove discrimination.

In this case the government can act. The government can say that you cannot discriminate and also the people that you have discriminated against we are going to provide them with greater opportunities. So, that they get a level playing field from background and. So, the government can sometimes improve the market outcomes.

And so to sum up, when we talk about wage determination the neoclassical theory of distribution says that the amount paid to each factor of production is derived from the demand and supply for that factor.

The demand for a factor depends on its marginal productivity and in equilibrium each factor of production earns the value of its marginal contribution to production. This is what the neoclassical theory of distribution says.

But we have observed in this lecture that the results of the neoclassical theory can get modulated by the compensating differential say in terms of more wages for difficult jobs or it can get modulated by the quantum of human capital how much is the amount of education and the training with the person it get modulated by the ability of person whether hereditary or otherwise by the effort a person puts in the chance factors whether the market is booming or in recession.

The appearance of the person can be modulated by the superstar phenomenon in those sectors where everybody wants the best product and these products can be made available cheaply to everybody.

They can get modulated by the minimum wage laws by the unions by the use of efficiency wages by firms or because of discrimination. So, there are a number of factors that can modulate the results of the neoclassical theory of distribution.

That is all for today. Thank you for your attention. Jai Hind!

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Module 10
Labour market economics and Conservation
Lecture 3
Income inequality and poverty

Namaste! We carry forward our discussion on Labour Market Economics and Conservation and in this lecture we shall have a look at Income Inequality and Poverty. We have seen before that poverty is intimately related to land and environmental degradation.

This is because poverty increases the amount of pressure on natural resources, because of which an over exploitation of natural resources becomes much more likely. Whether it is for fuel good or it is for agriculture or it is for meeting their daily needs of different people.

Poverty is intimately related to a lack of resources which might lead to an over population especially in the earlier stages of the demographic transition. Because of all of these there is an abundance of pressure on land and natural resources, because of which there is land and environmental degradation. This is the reason why it is very crucial for us to understand why poverty is there and what are the things that lead to poverty?

One very important topic when we talk about poverty is Income Inequality. Income inequality is the disparity of income distributions, it is the disparity which means differences in the distribution of income with a high concentration of income usually in the hands of a small percentage of the population.

When we say income inequality it means that there are some people in a society that have the largest amount of resources with them, they have the largest amount of money and the most assets with them. Whereas a large portion of the society has to go with very little amount of resources.

So, it is a disparity of the income distributions with a high concentration of income usually in the hands of a small percentage of the population. It means that even though the society in total would be having a large amount of resources, but because these resources are concentrated in the hands of a few people. In that case a large number of people would be poor and this poverty might lead to degradation of the land and the environment.

It manifests itself in wealth disparity, disparity in standards of living and disparity in human development indices. It results in a disparity in wealth that is the amount of money that people have disparity in the standards of living. In the same society you can have people who are using LPG or say electricity and you will also have certain people who are using fuel wood and disparity in the human development indices.

And disparity in the human development indices is one of the major reasons why poverty continues, because a person who is born into a family that is poor has less access to things like education or health.

In the absence of education or with a little amount of education this person would have little chance to move up in the economic ladder. So, a lack of education would mean that this person would not be earning large amounts of money when he or she grows up and that would mean that this person would continue to remain poor.

Similarly, in the absence of sufficient health infrastructure and access to health services, it is also possible that the person remains sick for a large portion of his or her life which would reduce their efficiency and with a reduced efficiency a person's ability to earn also reduces, which also keeps the person more and more into poverty.

Now, income inequality can be observed at the global stage and also at the local stage. So, when we talk about inequality in the world there are certain regions of the world such as most of North America, most of Western Europe and Australia and Japan that have a large amount of per capita income.

The people here earn much more as compared to countries in Asia or countries in Africa or some countries in South America where the per capita income is less and because the per capita income is less. The wealth levels also become very less.

The total assets that are there with people and the resources that people have are also less. So, we can observe that in the world stage there are certain rich areas and there are certain areas where people are mostly poor.

In our country we find a major difference in terms of the kinds of employment that people have. There are certain occupations where people get a regular source of income through their employment.

On the other hand there are certain people who work on a casual basis, which means that on some days they would be getting an income and some on some other days they will not be getting their income.

In our country if we look at the distribution of workers we will find that around 52 percent of people are self-employed, around 23 percent of people are having regular wages, that is they are working a regular job they may be salaried people and around 25 percent of people are casual labourers.

Now, these kinds of labourers may get an income on some day, on some other day they might not get any income. When we talk about this the people who are self-employed include professionals such as doctors and lawyers, but it also includes a large number of poor people especially the small shopkeepers or people who till their own lands the agriculturalists.

So, these people are self-employed, they are not working for wages, they are not working with someone else and at the same time they are not casual labourers. But in a large portion of these people who are self-employed the per capita income is very less and the people with a regular source of income are just around 23 percent of our population.

If we look at changes over time, the number of self-employed or the percentage of self-employed has hardly changed in between the years 2011-12 to 2017-18.

But the number of regular wage waged people or the salaried people has increased and the number of casual labourers has decreased, which in turn can be said to be a positive development. Because now more and more people are having regular sources of income.

This is the status of employment. If we look at the income share of people. Here on the x axis we have the decile, now decile means that when we talk about 1 it is the bottom 10 percent of the population.

The 10 th decile is the top 10 percent of the population, now with this curve we can observe that the top 10 percent of the population is having an income share of greater than 60 percent. Whereas, the bottom 10 percent of the population is having an income share of less than 1 percent.

This is a representation of the income inequality that we have in our country. There are certain people who are in the top 10 percent of the population who have a major share of the total earnings of our country. More than 60 percent of the income is being earned by only 10 percent of the people.

On the other hand there are other people who fall in the bottom 10 percent who do not earn even 1 percent of the earnings of the country. So, this is a good indication of the income inequality in our country.

We can convert this curve into the cumulative income state. Now, when we talk about the cumulative income share, what happens here is that when we talk about the 2nd decile. We are adding the income of the 2nd decile plus the income of the first decile. So, it becomes an increasing curve.

The 3rd decile will include the incomes of everybody in the bottom 30 percent of the population. So, in this case we are adding up the incomes. When we talk about the 10 th decile it will include the income of 100 percent of the people of India.

Essentially what we are observing here is that in the 10 th decile we have a 100 percent income share. If we talk about the 5 th decile it is the income of the bottom 50 percent of the population. Here we can observe that the income of 90 percent of the people of our country comes to around 40 percent of the total income of the country.

This is just another way of representing the income inequality that we were seeing so this was income share and this is a cumulative income share in percentage. Now, cumulative income share ensures that in the 10 th decile we reach a value of 100.

This is important because we can use a curve like this to compute the Gini coefficient of the country. If there was absolutely no income inequality, that is if everybody was earning the same income. What would have happened?

In such a scenario if we talk about any 10 percent of the population they would be earning 10 percent of the income of the country, 20 percent people would be in 20 percent of the income, 50 percent would be in 50 percent of the income and this is being represented by this straight line.

If we look at the 5 th decile it would reach 50 percent. If we talk about the 10 th decile it would be 100 percent. This is a 1 on 1 correspondence.

If the income of the country was distributed in such a manner that there was absolutely no income inequality, then these bars would have been touching this line. This is the line that shows

absolutely no income inequality, on the other hand this is the curve that is representing the data in these bars. This is no income inequality and this line is showing the actual position.

Gini coefficient is defined as this portion A divided by A plus B that is out of the total area of this triangle, how much of the area has been left out which is this portion A. So, this gives us the Gini coefficient of inequality.

If there is more inequality in the country in that case this curve would shift to this side and in that case the amount of A would increase and when A increases we will have more inequality. When A decreases when these curves just touch this line in that case A will be 0 and when A is 0 we will have a Gini coefficient of 0.

Gini coefficient is a way of representing the income inequality by a single number and this is how the Gini coefficient is determined. We find out the cumulative income share of the country, draw the straight line between different deciles and find out these 2 areas.

One thing is very clear that in our country we have income inequality. We saw that there is income inequality at the global level and we also have income inequality at the national level. Now, this income inequality manifests itself in the form of a number of indicators.

If we look at the indicators of inequality, this is data from the economic survey of India and if we look at the per capita net state domestic product at current prices that is 2011- 12 series as on date first of august 2019.

What we are observing here is that for any state we can find or say for most of the state what we will find is that the per capita net state domestic product has been increasing with time. That is overall the income levels of people has been rising, because the total produce of the state has been increasing and it has been increasing at a rate that is faster than the growth of the population.

Which is why we are observing an increase in the per capita state domestic product. But if we look at different states for any year, let us see 2011 and 12. The per capita net state domestic product for Andhra Pradesh is 69000 rupees.

But for Goa was more than 2 and half lakhs of rupees, for Haryana it was above a lack of rupees. So, what we are observing here is that different states are having different per capita net state domestic product. In the case of Bihar it was less than 22000 rupees.

The per capita net state domestic product of Bihar was less than 10 percent of that of Goa, which is telling us that there are certain states in which people are earning way more than what people are earning in the other states as much as a greater than 10 times difference. This is how we can observe the income inequalities at the state levels.

Even within the country we are observing that different states have been having very different per capita state domestic product and for most of the states though it has been increasing, but still we are finding that there are large differences.

If we look at 2017-18 Bihar the figure is less than 39000 rupees, but for Goa it is around 422000 rupees. Here again even though both have increased in their per capita net state domestic product. So, Goa has increased from 260 to 422 Bihar has increased from 21 to 38, but still the inequality remains.

Another indicator is the social indicator such as the life expectancy at birth. While the life ex-

pectancy at birth in the year 2013 to 17, if we look at Bihar it is 68.9 years but in Maharashtra it is 72.5 years, in UP it is only 65 years, whereas in Kerala it is 75.2 years.

So, people in different states are having different life expectancies. Now, this is one result also of the amount of income that different people have in different states, because if people are earning more they can have access to more resources, say better healthcare or health care for a majority of the people. So, these things would increase the life expectancy.

Another indicator is the infant mortality rate that is out of every 1000 live births how many infants die in the first year. Now, here in the case of Assam the figure is 44, in the case of a state like Kerala the figure is 10. So, a child that is born in Kerala is having a much less chance of dying than a child that is born in the state of Assam, or a child that is born in the state of Madhya Pradesh. So, this is also because people in Kerala are earning more, they have better health services, they have much better antenatal care. Even before a child is born the mother is attended to and she is given medicines she is given adequate nutrition.

The income inequality will manifest itself in terms of differences in the human development indices of different states, differences in birth rate, differences in death rate. So, if we look at now a more developed state such as Kerala the birth rate per 1000 is only 14.2, whereas in a state like Madhya Pradesh it is 24.8. So, it is roughly double in the case of Madhya Pradesh.

If we look at total fertility rate in the case of Kerala it is 1.7, in the case of Madhya Pradesh it is 2.7 a large difference in the case of Uttar Pradesh it is 3.0, in the case of Bihar it is 3.2. What we are observing here is that there are different inequalities not only in the economic criteria, but also in the social criteria, in the demographic criteria and to a large extent these are also related. Because what we have observed in the case of demographic transition is that when a society progresses. So, it has become more developed. In that case the birth rates would be less, the death rates would be less, the growth rates of population will be less and people will be spending more time in school. People will be having access to better health. So, better health and better education. We are observing all these different criteria in the social indicators.

Another indicator is the number of recognized educational institutions in the country in terms of different states. So, here we can observe that the number of education institutions in a state such as Karnataka is much greater than what we have in Arunachal Pradesh or in a state like Meghalaya.

Similarly, if we look at universities we will find that there are certain states that have a very large number of universities such as Karnataka and there are certain states that have less number of universities such as Nagaland.

So, there are differences everywhere the number of recognized educational institutions in a state such as Uttarakhand we have only 2 institutes under the ministry under different ministries, whereas in West Bengal we have as high as 12.

Now, what is happening here is that the more the number of institutes that you have in terms of educational institutions or institutions under the government, the better is the opportunity that is available to the people that are residing in those particular states. So, they have access to more institutions, they have access to more educational institutes, or training institutes where they can learn things or if we have a look at the state wide literacy rates.

If we take any state in a large possibility their literacy rates would be going down. So, if we look at Jharkhand it was 12.9 percent in 1951 and now it has reached as high as 66.4 percent. But then here again there is a difference.

If we look at a state like Kerala in 1951 they had 47.2 percent literacy rate a state such as Madhya Pradesh had to reach till the year 1991 to reach that state.

In the year 1991 we had 44.7 percent literates and Kerala was having a much greater percentage way back in 1951.

Now the literacy rate means that people have access to more job opportunities, they have access to newer technologies, newer developments they can incorporate or they can imbibe any new developments much faster because they are literates. And even today we can find that there is a difference in the literacy rates across different states.

In a state such as Bihar the literacy rate is 61.8 percent; in the state of Himachal Pradesh it is around 83 percent; in Kerala it is 94 percent. Here again what we are observing is that we have different indicators that are showing that different states are not the same.

There are differences or if we have a look at the number of households or the percentage of households with access to safe drinking water in India. In the state of Andhra Pradesh as many as 90.5 percent of households had access to safe drinking water in the year 2011. This is the census data.

But in 2011 they had 90.5 percent of people with access to safe drinking water, in the state of Haryana it was 93.8 percent Himachal Pradesh 93.7 percent, but in the state of Jharkhand it was as less as 60.1 percent.

If people in a state do not have access to safe drinking water, it means that there is a greater possibility of those people falling ill to waterborne diseases. These indicators tell us what is the state of living in different states. A person who is much more probable of falling ill because of waterborne diseases will probably not be that efficient than a person who is safe from these diseases. Because ultimately when a person falls sick the efficiency to do this reduces. People will have to take leave and so these are all different indicators that give us an idea of the level of income that people will be having.

If people have more access to health and education, their incomes will go on increasing. If you look at the population in different states it is different. If you look at population at in under different age groups child sex ratio, now child sex ratio is also a very good indication of the level of development of the society. Because if the society is giving equal weight age to the girl child and the boy child in that case we will find a much higher child sex ratio.

It would tell us that there are very less cases of female infanticide or female feticide and this is what we are observing. Indicators such as these can help us determine the level of development of different states.

In a state such as Gujarat is having a child sex ratio of 890, Haryana is having 834. But if we look at more developed areas such as Kerala you have the figure of 964 in the case of Karnataka it is 948. So, these are also very good indicators of the differential roles of different factors in different states.

So, a state that has a better child sex ratio probably has more women as compared to that of men,

which would mean that later on with these girls get into the age of employment they will be having better chances of getting an employment which would mean that they would also be earning. In a family when more and more people are earning the income would grow up for the family as a whole. Whereas, for a family in which only the male members are earning the income is just half.

Similarly we can have a look at other factors such as the percentage decadal growth or the sex ratio at birth or the school education quality index and all these factors are different between different states. And these differences will also manifest themselves in terms of all these different maternal mortality ratios. Under 5 mortality ratio education that people are getting and so on.

This brings us to the topic of poverty, when we have an income inequality then in the same state or in the same society we will have certain people with more income, certain people with less income certain people with more wealth certain people with less amount of wealth. That brings us to the definition of poverty.

Poverty is a state or condition in which a person or community lacks the financial resources and essentials for a minimum standard of living. So, poverty is a state or it is a condition in which a person or community. What it means is that we can have poverty at the level of a person or we can also have poverty at the level of a community. Which means that in a community there can be certain people who are rich and certain people who are poor or we can have a community that itself is rich or poor.

We have observed that in the case of different states there are certain states that have more resources. We will say that those are the richer communities and there are certain states with lesser resources and we can say that those are poorer communities.

And poverty will be defined as a state or condition in which a person or community lacks the financial resources and essentials for a minimum standard of living. So, we are not talking about a very luxurious life, but we are saying that the minimum standards of living; how easy it is for people in those communities to meet the minimum standards of living.

In this case we can define 2 different kinds of poverty: absolute poverty and relative poverty. Absolute poverty is a condition characterized by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter education and information. So, absolute poverty is characterized by a severe deprivation of basic human needs.

On the other hand relative poverty is a condition where a household income is lower than the median income in the particular country. So, the difference between absolute and relative poverty is that absolute poverty says that people are unable to meet the basic requirements.

Whereas, relative poverty says that even in a community that people are able to meet their basic requirements, there will be some people who have more income and some people who have less income. So, the people who are earning less than the median income would be said to be poor, in terms of relative poverty.

So, a condition where a household's income is lower than the median income in that particular country is the people who fall in the bottom half. We will say that they are the relatively poor people in that community or that country. So, it is possible for a person to be relatively poor, but not absolutely poor.

Because in the case of a person who is relatively poor, but is having access to sufficient amounts of nutrition, sufficient access to health, and a sufficient amount of education, but still there are people in that community that are earning way more. So, in that case we will say that this person is not absolutely poor, but he is relatively poor when compared to others.

At the same time there can also be a situation where everybody is absolutely poor and in that case it is possible for a person to be relatively rich, but absolutely poor. Which means that the community in itself is having such a huge lack of resources that even the best of people are unable to meet the basic human requirements of health education information and so on.

This is the difference between absolute poverty and relative poverty. Absolute poverty talks about a severe deprivation of basic human needs and relative poverty talks about the comparison with other people in that country or community.

Now, absolute poverty depends not only on income, but also on access to social services. Which means that you can have people who have a very small amount of income, but if they are provided the basic human needs of shelter, education, nutrition and so on by say the government or they are provided these amenities by say an NGO then they will cease to remain in absolute poverty.

Even though their income levels are very low, which means that we can eliminate absolute poverty by things such as providing nutrition to people or providing shelter to people or by providing a certain amount of money to these people.

So, absolute poverty depends not only on income, but also on access to social services. In our country absolute poverty refers to per capita consumption expenditure level, which does not meet the average per capita daily requirement of 2400 calories in rural areas and 2100 calories in urban areas along with a minimum of non food expenditures.

Which means that in our country we say that a person is absolutely poor, when he or she is not able to meet the minimum nutritional requirements and certain other requirements. We would also mean that if the government provides everybody with minimum nutritional requirements, that is the government provides food grains at cheaper cost, then we can pull people above the poverty line.

That means, we can bring them away from absolute poverty. This is why these two definitions become important. And in this context we define the poverty line, it is an absolute level of income set by the government for each family size below which a family is deemed to be in poverty.

It is an absolute level of income, which means that we are talking about absolute poverty, we are not talking about relative poverty. The poverty line is an absolute level of income that is set by the government, for each family size because if somebody has a larger family then probably they will require more income. And if the income of the family is less than this absolute level that is set by the government for that family size, then we will say that this family is below the poverty line.

And in this context we also define the poverty rate or the head count ratio, poverty rate is the percentage of the population whose family income falls below an absolute level called the poverty line. That is when we are talking about the poverty rate we are asking the question of all the fam-

lies in our country or in a state. What is the percentage of families that are below the poverty line? That is they are below this minimum criterion or the minimum level that has been set by the government.

More the number of families that are below the poverty line more will be the poverty rate also known as the head count ratio. And in our country if we look at the head count ratio it has been decreasing over time.

In 1973-74 around 50 percent of people in urban areas and even more so the number of people in the rural areas were below the poverty line. But in the year 1999- 2000 this figure had come down to less than 30 percent.

So, the poverty rate was roughly half in a quarter of a century. This is the head count ratio, the percentage of families that are below the poverty line and with time because of development more and more people are now moving out of the poverty line.

But if you look at the number of poor in millions, then it presents a somewhat different picture. If you look at the number of rural poor then we will find that this number has been going down. But if you look at the number of urban poor we will find that this number went up and now it is showing a downward trend.

Now, why do we see this increase in number, now this increase in number can be because of 2 reasons: one is that these people are not running enough, that is the incomes of certain groups of people are becoming less. So, that they are moving from above the poverty line to below the poverty line, now that can be one reason.

But another reason that is more prominent in our country is that because of migration people move from rural areas to the urban areas and in a large number of cases the people who shift from rural areas into urban areas are the poor people, who are looking for casual employment.

Say employment: in employment as a street seller or employment as a household worker or employment as a casual labour in a factory, employment as a porter. Now, these people who were extremely desperate who were extremely poor were living in the rural areas and they shifted to the urban areas in search of employment.

In such a scenario the number of urban poors would increase because more and more rural poor are moving into the urban areas. But the good thing is that the poverty rate has been going down with time.

When we are talking about poverty it is important to remember that people can move into and out of the poverty line, that is there can be times where people are more poor and there can be times where the people are less poor. A good example is the agricultural sector.

In the agricultural season more and more people get employment in the fields. When they get work they get a certain amount of money, but at the end of the agricultural season when there is no longer any need for the workers or there is very little need for workers in those times these people lose their jobs and in that case they become poorer.

So, we have certain categories of poverty, the first category is always poor. If this is the poverty line that is on the y axis we have the income on the x axis we have the time and if this is the poverty line and if the income of a family or a household is it is going up and down with time. But at all points of time it is below the poverty line then we will say that these people are always

poor.

On the other hand we can have situations where people are usually poor, which means that for a large portion of the time they are below the poverty line. But there can be instances where they move above the poverty line. In this case they are usually poor, they are not always poor.

Then the third category is that of churning poor. So, these are those households that are regularly moving in and out of the poverty line. For certain periods of time they are below the poverty line and for certain periods of time they are above the poverty line. This is known as churning poor.

On the other hand we can also occasionally have poor people, which means that for the most part they are above the poverty line. But in certain points they move below the poverty line. And then we have the category of never poor of those people who are always above the poverty line.

It is important to note here that poverty is a dynamic phenomenon that can change with time. So, a person who is absolutely poor can become a non poor in certain seasons when they are getting employment or probably when they get remuneration by selling agricultural produce.

There could be certain points of time where these people are no longer poor, but then there are the people who are not poor they can also move into the poverty line. So, this is a dynamic concept.

The next thing to note is that the income distribution and poverty rate do not completely quantify the inequality. Now in this case we are interested in conservation economics to know the situations or the circumstances where poverty would lead to a greater environmental degradation.

What we have seen so far is that when people are poor then the amount of pressure that each household puts on the environment in certain cases is much greater than if these people are moved out of the poverty line.

But then this is not the complete story. Basically we can say that people who are very rich are also putting a very large amount of strain, people who are very poor are also putting a very large amount of strain. But then the people in between are putting probably a lesser amount of strain on the environment. How can we make those people who are very poor a little less poor? Is income the only criterion? The answer is no, because what matters is not the income but the ability to maintain a good standard of living.

Essentially if there is a household that is earning less, but we are able to provide it with education and health services, adequate nutrition then probably we would be able to shift them from the very early stages of demographic transition probably to a later stage, that is we are interested in making these people a little less poor by providing them with all different sorts of facilities that are necessary for the maintenance of the minimum basic standards of living so that the amount of pressure that this household is putting on the environment reduces, that is probably we increase their living standards to such an extent that it is now possible for them to say purchase fertilizers. So, their crop productivity increases and the amount of pressure that they are putting on the forest reduces.

Because they now no longer require very large portions of land, because of the productivity increases or with adequate amounts of health services and education. We can make them come to the conclusion that yes our children are going to survive. It is not the case that the majority of our children are going to die, which means that even if we have 1 child or 2 children they are going

to reach adulthood.

Now, there is no longer a need to have a larger family. So, if that is our aim to use the concepts of poverty to aid conservation, then how do we analyse this situation is providing income the only way out the answer is no. So, what matters is not the income, but the ability to maintain a good standard of living and this ability is also affected by things such as in kind transfers.

In kind transfer is transfers to the poor given in the form of goods and services rather than cash, which means that in place of giving the poor people with money directly to purchase food at the normal market prices.

What the government does is that it provides them with a certain amount of rations every month either free of cost or at a very nominal rate and when the government does that it is able to raise their nutritional level of standards.

Similarly, the poor people get access to health facilities. So, even though they might not be able to afford a private doctor in say a city, the government ensures that there is a hospital that is set up in their community and also that doctors are appointed there so that the poor people are also able to get access to good health services.

Similarly, the government puts a lot of emphasis on opening up educational institutions, primary schools in areas that are more poor and more backward. The government puts a lot of emphasis on setting up things such as clean sanitation or provisioning of clean water in areas that are very poor.

In this case the government is not providing money to the people, but the government is providing them with facilities in the form of in kind transports and those are also able to raise the standards of living. So, when we saw here that the head count ratio has been going down, a major factor is also because in our country the poverty line is defined by the amount of nutrition that people get 2400 calories in rural areas and 2100 calories in urban areas.

But with the government programs and policies we have been able to provide people with this amount of rations, so that they are able to get this amount of nutrition. Another thing is the economic life cycle, the regular pattern of income variation over a person's life. So, we observed here that there is a regular pattern of variation in income.

In certain points of time people have more money, in certain points of time they have less money and a very important thing in this case is retirement. Now, people earn money when they are in the employable age, but when people become old then they do not find employment. So, in that case their income reduces by a very drastic amount. Because of that, retirement planning is important.

So, the income is less to begin with, then it rises with age and sharply reduces on retirement, if retirement planning is done properly a decrease in income will not reflect as a decrease in the living standards. And this is what the government is also emphasizing these days. So, the government has brought up a number of programs that provide people with facilities for better retirement planning things like old age pensions.

Another point is the permanent versus transitional income, so a person's normal income versus the income in a particular time period, such as drought or flood or market upheaval. The standard of living is more dependent on the permanent or average income while transitional changes can

be smoother now using loans etcetera.

When we talk about this permanent versus transitional income, we are interested in this portion. So, there are certain people who are occasionally poor, that is for a large portion of the time they are above the poverty line, but because of certain market fluctuations or things such as drought they might move into the poverty line.

When a person moves from above a poverty line situation into the poverty line, then it is also possible that their living standards do not go down drastically. Why because they have access to funds in the form of things like loans. So, in this case the average income of a person is more important than transitional income.

Even if transitional income goes down, if we are able to ensure that people have a good amount of average income, then that will be helpful to the people. Now, next we come to the normative question should income be redistributed. So, when we talk about poverty although one way of reducing poverty is by taking the money from the rich people and giving it to the poor people, the question is should the government do it. Now, this is not just a question of economics it is also a question of philosophy and a question of quality.

And in this case we have several schools of thought, the first school of thought is utilitarianism, it is the political philosophy. According to which the government should choose policies to maximize the total utility of everyone in the society, where utility is defined as a measure of happiness or satisfaction.

So, utilitarianism says that the aim of the government should be to keep the maximum number of people happy or satisfied. Now, in this case because we have the law of diminishing marginal utility it means that a person who is having a large amount of income is probably gaining a lesser amount of happiness or satisfaction with each increase in the income.

But in other words what we are saying is that if there is a person who is earning say 100000 rupees or 1 lakh rupees and if the person shifts to earning 101000 rupees now this is case 1. The second case is a person who is earning say 200 rupees and he is also earning 1000 rupees more so 1200 rupees so this is case 2.

In this case what happens is that a person who is already earning a large amount of money 100000 of rupees in for this person this change of 1000 rupees it will not lead to a very large increase in happiness, because percentage wise this change is very less and also the resources or the utilities that this person wants to have in his life they have mostly been already accumulated. So, this 1000 rupees will not make a very big change in the life of this person. But if you look at case 2 a person who was earning just 200 rupees you give him 1000 rupees and he is now earning 1200 rupees.

In this case there is a 6 fold change in the income. So, even though the absolute change is only 1000 rupees in both the cases, in the first case the change is very minuscule around 1 percent; whereas, in the 2 nd case it is as high as 6 times. So, utilitarianism would say that there is a case of taking money from the rich people and giving it to the poor people. So, in total the amount of happiness or satisfaction in the society increases.

Because of the law of diminishing marginal utility the utilitarian perspective would say that income redistribution will help maximize the utility of the society. So, this is one school of

thought. Another school of thought is Liberalism, the political philosophy according to which the government should choose policies deemed as just.

So, the government should make those policies that are just policies as evaluated by an impartial observer behind a wheel of ignorance. What liberalism says is that the government should be interested in making just policies that are fair policies and fair policies that are judged by an outsider. An impartial person who is behind a wheel of ignorance, which means that this person should not know whether he himself belongs to a rich class or a poor class.

Suppose a person is given this option that he can be born into a rich family or he can be born into a poor family, but he does not know whether he will be born into a rich family or a poor family. Now if you ask this person to make the laws or the policies then probably those will be the best policies, because this person would take care of the interest of both the rich as well as the poor. So, these will be fair policies.

Because he might be born as a rich person in which case if he had made policies to favour only the poor then he will be negatively influenced. On the other hand he may even be born a poor person. So, if he had made policies that favour the rich in that case he would be negatively impacted.

So, given that a person does not know whether he will be born rich or poor and if you ask such a person to bring the policies, those will be the most fair policies. So, this is what liberalism says and it talks about the maximin criterion or maximizing the minimum utility.

So, the people who have the minimum utility and the fair policies would try to maximize their utility, the claim that the government should aim to maximize the wellbeing of the worst off people in the society. So, in the case of liberalism it says that the government should try to help the most poor people and while this criterion suggests income redistribution. So, some amount of income redistribution is ok according to liberalism.

The veil of ignorance would suggest that complete equality would remove the motivation to work to the detriment of the society. So, liberalism says that yes some amount of income redistribution should be done, but it should not be done to equalize everybody, because if everybody is equal then there will be no incentive for people to become rich to work hard and we want people to work hard so that the society progresses.

And so there has to be some amount of inequality, but then this inequality should be maintained in such a manner that the poorest people also are not very bad often, that is they also have abilities to meet the minimum standards. So, this is liberalism.

It suggests that some income redistribution should be done, but some inequality should remain to motivate people to work and redistribution of income should be done in the form of social insurance. So, the worst of people are also protected.

Social insurance is the government policy that is aimed at protecting people against the risk of adverse events. Social insurance is a government policy aimed at protecting people against the risk of adverse events. It means that when we make the policies, then liberalism would say that if somebody becomes very poor if there is, say, a drought, then there should be policies that help these people.

Another school of thought is libertarianism, the political philosophy according to which the gov-

ernment should punish crimes and enforce voluntary agreements, but not redistribute them. So, this is another extreme. It says that the role of the government is to punish crimes and enforce the voluntary agreements, but not to redistribute income.

Equality of opportunity is more important than equality of incomes and once the rules of the games are established the government should not alter the result. So, libertarianism says that the government should only be interested in making the institutions - maintaining the institutions that promote the rule of law.

But once you have the system then a person should be allowed to remain in whatever state he or she is in. So, if somebody is poor even though the system is just, if somebody is poor the government should not help that person. This is another school of thought.

What we are observing here is that when we talk about income redistribution we can move from utilitarianism which says that everybody should be made equal to maximize utility to the other extreme which is libertarianism which says that even if somebody is poor we should let that person remain poor. So, this is a normative question.

Now, because the government is interested in reducing poverty in our country we are more towards liberalism than either of the 2 extremes, so we take the middle path. So, the government tries to reduce poverty and the government reduces poverty or it tries to reduce poverty by a number of measures such as the minimum wage loss.

It says that people have to be paid a minimum amount, but as we have seen in a number of cases it results in surplus. Apart from minimum wage laws we have welfare policies which are government programs that supplement the income of the needy, such as things like old age pensions or disability pensions. So, people who are very old or people who are disabled they are provided with a certain amount of government money to supplement their incomes because they are needy.

We also have negative income tax which is a tax system that collects revenue from high income households and gives subsidies to the low income households. So, in our country as well we have income tax that is a progressive tax which means that if somebody is earning more than a larger share of income is taken from that person.

But at the same time the government also provides subsidies to the poor people. So, negative income tax is also used in kind transfers are used such as provisioning of food grains at subsidised prices and we also have anti poverty programs and work incentives such as the Mahatma Gandhi National Rural Employment Guarantee Scheme, but to bring the income inequality to 0 or not still remains a political question.

That is all for today. Thank you for your attention. Jai Hind!

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Module 11
Practical issues in Economics and Conservation
Lecture 1
Consumer choice

Namaste! Today we begin a new module which is practical issues in Economics and Conservation. This module will have 3 lectures: consumer choice, asymmetric information and behavioural economics and valuation of natural resources. So, let us begin with Consumer Choice. Some of you may have observed this mark on some of the products that you are purchasing. This is an eco mark and this mark designates or certifies that the product that has this mark has been made with the least impact on the ecosystem which means that whenever you see this mark on a product, it means that it has been made in a sustainable manner without putting a very great amount of stress on the environment.

Similarly, if you observe a mark such as this one; this is the mark of India organic. This is telling that the product that has this mark has been made using organic techniques, organic agriculture without the use of things such as pesticides. Now this is important because we have observed that pesticides are back bio accumulative toxins that also magnify when they move up the food chain. And so, when you purchase something that is labeled as organic; it is not just good for your body, it is also good for the ecosystem.

Similarly, we have marks such as these; this is the FSC mark of the Forest Stewardship Council. Now when you have a label like this, it states that 100 percent products are containing the material from FSC certified forest that meet the environmental and social standards of FSC.

100 percent of the material that is having this mark of FSC and when it says 100 percent, it means that the product is containing materials that are from FSC certified qualities that are meeting environmental and social standards. When we say that it is meeting an environmental standard it means that it is being taken out in a sustainable manner. There is no excessive use of chemicals in such a forest. It has been harvested in such a manner that the biodiversity is protected and it also meets the social criteria which means that the benefits are being shared with the community. It is not taken from a forest that is being worked through exploitation of labor.

Similarly if you have this FSC mark with mix it states that it has products with material from FSC certified forest recycled materials or other controlled sources. Here again this label is certifying that the product that is being bought is from a sustainably managed resource. So, it is good for the environment. We have FSC recycled label products containing post consumer material and may include some amount of pre consumer material.

We have labels like these. When we say that we have this 100 percent label, it means that it is only from FSC certified forest. If you have a mixed label, then it is from if this is certified forest FSC controlled wood or reclaimed material that is the recycled material. And when we say recycled, it is from reclaimed materials.

If there is a product that has this label, then it means that it is good for the environment. Similarly, we have the labels of rainforest alliance. Now the rainforest alliance again says that the product has been extracted or manufactured in such a manner that it protects the biodiversity of the rainforest or we can have a label like this ISO 14000 family.

Now, ISO 14000 label means that it is a label for environmental management and there are a number of companies that are highlighting their sustainability. Brands such as Apple making without taking sounds impossible, but it is our goal and it says that 100 percent of our offices, retail locations and data centers have run on 100 percent renewable energy. And if you download this report you will find what all steps are being taken by this company for maintaining and enhancing the level of sustainability. Here for the environment.

If we look at the website of Tetrapak, it says it has this FSC label. So, it says that all our paper-board comes from wood from forest certified to FSC standards and other control sources. You know tetra pak is highlighting the fact that when it is making the products and its products contain paper and good materials.

In that case it is only taking those materials that are being extracted in a sustainable manner. So, it is caring for the environment. So, brands such as Apple and Tetrapak are emphasizing that they are caring for the environment. Or Maruti Suzuki, it says the future begins now with BS6. So, BS6 is Bharath Standard 6 which is an enhanced level of standardization for petrol and diesel vehicles and their fuels that ensures that the amount of pollutants that are released are less.

When Maruti Suzuki highlights it on its home page it means that it wants to highlight that it is a company that is caring for the environment. The question is if we have such standards and when we have companies that are highlighting these standards, is it sufficient?

By that what we mean is it sufficient to have standards and certain companies that show that or highlight that they are following these standards or is there something else that is also involved. After all, in a market economy the prices and the process of buying and selling are the things that give signals to the buyers and the sellers.

Now, on the one hand, there are certain companies that are showcasing that they are environmentally friendly, but then being environmentally friendly will also come at a cost. Because if you say shift from a certified forest, certification takes effort, certification takes cost and also there are certain other sources of unsustainably managed forests from which the wood can be had more cheaply.

Because they are not sustainably managed they are not being managed for a long term perspective. In the short term, they can prove cheaper. Similarly when we talk about things such as BS6 compliance, we also have this news. Last chance to buy BS4 discounted cars TATA Nexon, Renault Kwid selling for less money.

This is an article that is telling people that okay the world is shifting towards BS6, but then we still have stocks of BS4 and this is a golden opportunity for you to buy the BS4 cars because they

are cheaper. Especially because of the more stringent norms after a while, it will be impossible to sell the BS4 cars and so, now, these are available at a greater discount.

Now mind you if somebody buys a BS4 car and is using that car, for the next say 5, 10-15 years; this is one vehicle that will be giving out pollution at a level that is greater than that of the BS6 standard. Now as a consumer how do you decide whether you should go for a BS4 car or a BS6 car?

Because overall if we have the standards and if we have the companies that are highlighting that yes, they are caring for the environment. But when there are certain other companies that probably are not following the higher standards and if people flock to those companies or even in the case of those companies that are following the standards; if there are unsold stocks and people only want to go for those unsold stocks.

In that case will it be possible for the companies to have stricter norms to follow the stricter norms or is the market telling a very different picture? Similarly, this article BS4 Hyundai cars discounts of up to rupees 2.5 lakhs on center and so, many other models. The question for the consumer is whether he or she should go for cost or sustainability.

And this is a very important question when we talk about conservation because if we want to go for conservation; if you want to manage things in such a manner that we are able to extract the resources for a very long period of time. Sustainability just means that we will not just use the resource right now, but we will use it in such a manner that we can extract the resource for many years to come or providing many generations to come

Ultimately if somebody is going for a sustainably produced material, then they are doing something that is best in the long term interest. But then if the unsustainably managed product is available at a lower cost, how does the consumer react?

If the consumer reacts in a manner that would say that no, we only care about the cost; we do not care about the sustainability. In that case probably sustainability will be a lost cause which is why it is important to understand how consumers make decisions.

How does consumer choice work? Now, a consumer is always acting in a budget constraint. A budget constraint is defined as the limit on the consumption bundles that a consumer can afford. Essentially we had begun this course by saying that economics is the science of decision making because our wants are unlimited, but the resources to fulfill those bonds are limited and which is why we need to choose; we need to make decisions.

The limitation of our resources is depicted by the budget constraint because not everybody has all the money that they would need or that they would want. So, there is a limitation on the budget of every person and budget constraint is the limit, then limit on the consumption bundles that a consumer can afford.

Probably a consumer wants to have a consumption bundle that says that let me have the best house, let me also have the best car, let me also have the best clothes, but then probably the consumer is unable to afford this consumer this consumption bundle. So, the consumer will have to make a choice whether he or she wants to go for better clothes at the cost of a better vehicle.

Probably the consumer might say that okay, let me go for a second best vehicle and the money that I save is going to be used for better clothes or the consumer might say that no I am saving

for a house for my retirement and I am going to cut cost in the vehicle as well as on the clothes that I am using.

The consumption bundles can be indefinite, but there is a limit on these consumption bundles that is being put by the budget constraint. The amount of money that a person has and it is determined by how much the consumer can afford.

If the consumer gets more money, then probably the consumer will shift to a very different consumption bundle than what he or she is choosing right away. When we talk about budget constraints, let us look at an example. Let us say that a person has a budget constraint of 100 rupees, it means that this person only has 100 rupees available with them and there are two items in the market. We have samosas and we have lassi. Now samosa is available at 5 rupees per samosa and lassi is available at 10 rupees per glass.

Now, suppose the consumer buys 20 samosas now, in that case the consumer has already spent 100 rupees on samosas. So, this is spending on samosa. So, 20 into 5 is 100 rupees and if the consumer has spent 100 rupees on some users, he or she will have 0 rupees left for lassi because the total spending can only be 100 rupees; it cannot exceed 100 rupees.

Now, if the consumer wants to have one glass of lassi, this glass of lassi will cost him 10 rupees. And if it is costing him 10 rupees, then it means that 90 rupees are available to purchase samosas and in 90 rupees, this person can get 18 samosas. So, this is another consumption bundle. So, the first consumption bundle was 20 and 0, that is , the consumer could have 20 samosas and 0 lassi. Another consumption bundle is 18 and 1. So, he or she can have 18 samosas and 10 lassis or we can have another consumption bundle which is 16 and 2 and so on till we reach to this point of 0 and 10. Now, at this point the consumer is spending money on 10 glasses of lassi which is 10 into 10 in 100 rupees is being spent on lassis, 0 rupees is being spent on samosas.

And so, the consumer is getting 0 samosas. Now these are all different consumption bundles that are available to the consumer. They can also be a number of other consumption bundles. So, such as in this case the consumer can get 10 of samosas and 5 of lassis, but the consumer can also say that no I do not want so many so, I will only have say 5 samosas and 2 lassis.

Now this can also be a consumption bundle, but then this is a consumption bundle that is less than the budget constraint. Here the budget constraint is 100 rupees and if the consumer is only buying 5 samosas, that is 25 rupees and 20 lassi is 20 rupees. So, in this case the consumer is only spending 25 and 20 rupees. So, the consumer is spending only 45 rupees whereas, the consumer could have spent 100 rupees.

So, we can have any number of consumption bundles. There are some consumption bundles that are within the budget constraint and there are certain others that are outside of the budget constraint. So, probably the consumer might say that no I do not want 5 and 2. I probably want, say, 50 and 20.

Now for 50 samosas the cost will be 250 rupees and for 20 lassis, the cost will be 200 rupees. In this case the consumer would want to have an amount of 450 rupees. But this amount is not available with the consumer; the consumer only has 100 rupees.

If we plot these consumption bundles, we will find that here on the y axis it is the number of lassis, on the x axis we have the number of samosas and there are a number of points that are right

there on the budget constraint things like 10 lassi and 0, samosas or things like 20 samosas with 0 lassi. But you also have certain points that are here and these points represent those consumption bundles that the consumer may have.

But when the consumer has those consumption bundles, then he or she will be saving some amount of money that is they are not using the money to the fullest. At the same time there are certain points that are here which represent those consumption bundles that the consumer cannot afford because they are outside the budget constraint. So, they will require a sum of money that is greater than the budget that they have currently. This is the concept of budget constraint.

The next question is when we have this budget constraint, what determines whether the consumer will go for this point or this point or say ah this point inside? Of course, the consumer cannot have a point outside. This is not permitted, but the points that are inside are permitted and the points on the line are permitted. What determines which point is actually chosen?

This brings us to the concept of indifference curves preferences. Indifference curve is a curve that shows consumption bundles that give the consumer the same level of satisfaction. So, indifference curves are curves that show those consumption bundles that give the consumer the same level of satisfaction.

Basically what we are asking here is that suppose you are very much fond of sweet things, so you are much fond of lassi and you do not like samosas that much. Now suppose you were given the option of having say 5 lassis and then you are given another option.

What we are asking here is that you are very fond of lassis and the money that you have can buy you 5 lassis, but then when you buy 5 lassis the number of samosas that you will have is 0. The question is if you reduce your lassi consumption by 1 so, if you have 4 lassis, what is the number of samosas that you will have that will give you the same level of satisfaction as having 5 lassis and 0 samosas? And that will give you an indifference curve.

I'll probably even say that no, I am more fond of lassi. If the lassi is reduced by 1 ok in that case, I will need three samosas. If I have these 3 samosas then and 4 lassis, then that will give me the same level of satisfaction as 5 lassis and 0 samosas. Now when we have these combinations of 5 and 0 or 4 and 3 and so on and when we plot these, we will get to an indifference curve. So, indifference curve is a curve that shows the consumption bundles that give the consumer the same level of satisfaction.

Here we are talking about the consumption bundles and these are the consumption bundles 5 and 0, 4 and 3 and so on. So, this is an indifference curve. And this is what an indifference curve looks like. So, the red line is showing the budget constraint and the blue line is showing the indifference curve. So, in this case, what we are saying is that if the consumer is at this point; then the consumer gets 2 samosas and 9 lassi and at this point the consumer gets 7 samosas and 3 lassis.

If both of these are on the same indifference curve then both of these consumption bundles will give the consumer the same level of satisfaction. So, whether the consumer has uh 2 samosas and 9 lassis or 7 samosas and 3 lassis, the amount of satisfaction or the amount of subtlety that the consumer will have is the same. So, that is an indifference curve. And when we talk about an indifference curve, we can also have a look at the marginal rate of substitution.

The rate at which a consumer is willing to trade one good for another. That is we are asking the question here if you want to give up 1 lassi, so, here the difference is minus 1. What has to be added to the number of samosas? In this case, it is plus 3. Now the ratio of these is giving us that for each lassi 3 samosas need to be had. So, that is giving us the rate of substitution. The marginal rate of substitution is the rate at which a consumer is willing to trade one good for another and it is given by the slope at any point.

What we are saying here is that if you look at this indifference curve, then the slope at this point which will be given by this line, this slope. At this point is given by this line and the slope at this point is given by this line. So, these 3 lines or these 3 slopes are giving us the marginal rate of substitution. And here we can observe that here the slope is very high, here it is medium and here the slope is very less now.

What will that show? At this point when we have this slope, then this much amount of the good here needs to be had for this much amount of the good here. So, what we are saying here is that for a lesser number of samosas, we need to have more lassis. So, what we are saying here is that so many lassis are equivalent to such a small number of samosas or that the person can give up so many lassis just to have a few more samosas at this point.

This is expected because at this point the consumer is already having a very large number of lassis and a very less number of samosas. Now we have a concept that is known as the law of diminishing marginal returns which means that suppose you do not have any food and suppose the food that you are having is rotis.

So, currently you have 0 rotis now and you are very hungry. When you shift from 0 rotis to 1 roti, you get a certain amount of satisfaction because your hunger is getting filled up. Now after the first roti, you have the second roti, then you have the third roti and probably now you have had 5 rotis. Now when you move from 5 rotis to 6 rotis will the amount of satisfaction that you had here - because here you were adding just 1 roti and here also you are adding just 1 roti.

The amount of satisfaction that you get in this process is much greater than the amount of satisfaction that you are getting in this process because by the time you have had 5 rupees you are not that hungry and so, the amount of satisfaction that you are gaining with each additional roti is going down. So, you are getting a diminishing marginal return with each new roti. And probably after a while you will have a negative marginal return which means that you are now so full that when you are given one more roti, then you just hate to eat.

So, the roti is the same when you are hungry, you are having a very high value for it. As your hunger goes down, your value for the roti goes down and at a level of too many rupees, now you are having a negative feeling for any additional roti that is force fed. This is exactly what we are observing at this point. So, the consumer is having a very large number of lassis. So, now, probably the consumer is not putting that higher value on the lassi, but the consumer has had very less samosas.

So, the amount of satisfaction that the consumer will have with each additional unit of samosa will probably be much greater than the amount of satisfaction that they will have with each additional unit of lassi. And which is why the consumer at this stage you get a very small number of samosas can give up a large number of lassis which is what we are seeing in the case of the slope

as well. So, this is the marginal rate of substitution.

When we have reached this point then the consumer has had so many samosas that now the consumer is ready to give up so many samosas just to have a few units of lassi. This will give a slope like this; a very low slope. And at a point in between the consumer has had a middle number of samosas and an average number of lassis. And so, the consumer is practically ambivalent about whether he or she gets an additional samosa or an additional lassi. So, this is the marginal rate of substitution which is given by the slope of the indifference curve.

Now, indifference curves have certain specific properties. One: a higher indifference curve is preferred to a lower one since the consumer prefers to consume more of both the products. Now, this is an assumption that we are making for a large number of cases. This assumption is also true. What we are saying is that if there are 2 indifference curves, the one that is higher.

In this case, this curve is preferred over this curve. So, the consumer will also always want to have this higher curve and not the lower curve because at the higher curve the consumer is having more of both the things. Indifference curves are downward sloping since if one word is consumed less the other should be consumed more for the same level of satisfaction.

What we are saying here is that remember that in the case of an indifference curve, we are looking at the points that give the same level of satisfaction. Now for the same level of satisfaction if one good is reduced, then the quantity of the second good should be increased. When you have this situation that when one reduces, the other increases you will have a downward sloping curve.

Another property is that indifference curves do not cross, since it would create a situation where more of both goods gives the same level of satisfaction as less of both goods which cannot be true. What we are saying here is that if there are 2 indifference curves and if these curves were able to cut each other, intersect each other at this point, what would that mean? A and B are on the same indifference curve. Basically A and B have the same level of satisfaction; A and B give the same satisfaction B, B and C are on the same indifference of this curve. So, they also give the same satisfaction.

If A and B give the same satisfaction, B and C give the same satisfaction, then it would mean that A and C give the same satisfaction. But now if you look at point A and C, then in the case of C we have more of good 2 and we also have more of good 1 which means that the point C where good 1 is more and good 2 is also more is giving the same level of satisfaction as point A. We began with the assumption that the consumer is getting satisfaction from the consumption of these goods. So, more the amount of goods that is consumed more should be the satisfaction, but in this case we are observing that more of having both the goods is giving the same level of satisfaction as less of both the goods which cannot be true which means that these curves should not be able to intersect each other. So, indifference curves do not cross.

Another property is that the indifference curves are bowed inwards since consumers have more willingness to give up a good that they already have a lot of which is what we saw here that at this point when the consumer has a large number of lassis, then the consumer is ready to give up large quantities of lassis to have a few quantities of samosas. Whereas, at this point the consumer is ready to give up a large number of samosas to have a small amount of lassi.

Now when we have such a situation that you have a higher sloping MRS here, a lower sloping MRS here and at a middle level of MRS here, then this in total will give a curve that is bent inwards that is towards the origin. So, the indifference curves are always having this shape - they are bent.

In this context, we can talk about two specific indifference curves. One is the indifference curve for perfect substitutes two goods with straight line indifference curves. Now substitutes are defined as goods with the same indifference curve. A very good example is whether you have money in the form of rupees or coins.

If somebody gave you a 10 rupee note will you gain more satisfaction than if this was then if you were offered a 10 rupee coin. Well in a majority of cases, you will find I mean we are not talking about an exception where your valid is so full that you are finding it difficult to hold any more coins.

But in a normal circumstance, you will find that the amount of satisfaction that you get from a 10 rupee note is the same as the amount of satisfaction that you will get from a 10 rupee coin because both are giving you the same power to purchase.

Similarly, a 5 rupee note or a 5 rupee coin will mean the same and this is what we are showing here. On the y axis, we have rupee notes; on the x axis, we have the rupee coins now 10 versus 10. It is a straight line. So, any combination, if you reduce the coins by a value of 1, you should increase the note by the value of 1. So, these are perfect substitutes, they will have straight line indifference curves.

Another specific indifference curve is perfect complements and complements are defined as goods with right angled indifference curves. A good example is shoes.

Now, on the y axis here, we have the right shoe; on the x axis we have the left shoe. Now if you were given this combination of this point 5 and 5. So, you are having 5 left shoes and 5 right shoes. Essentially you are having 5 pairs of shoes. Now suppose in place of this, you were given this combination. So, here you are having 6 left shoes and 5 right shoes.

In this case, what is happening is that here also you are having 5 pairs of shoes and an extra left shoe. Now here is well you get 5 pairs of shoes in an extra left shoe. So, the amount of satisfaction that you get will be the same as the amount of satisfaction when you are having the 5 pairs of shoes because you do not have an extra utility for an extra left shoe. Similarly if you had 7 left shoes and 5 right shoes, here also the number of working pairs is only 5 and you have an extra 2 left shoes which you do not have a use for.

Whether you get this combination 5 and 5 or this combination or this combination it is one and the same you get the same level of satisfaction because you only have 5 pairs of shoes in each case. Similarly if you look at this point, you have 5 left shoes and 6 right shoes here again you have 5 pairs of shoes and then extra right shoes. At this point you have 5 pairs of shoes and 2 extra right shoes.

Now these three points provide the same level of satisfaction. Because in all these three points the number of working pairs of shoes is only 5 and similarly all these give the same level of satisfaction. Combining both of these right - these two straight lines at 90 degrees they give the indifference curve for perfect complements.

Perfect complements means that you cannot substitute one for the other, but you need both of them together. In the case of substitutes, you can replace one with another, but in the case of complements you need both of them for working things such as nuts and bolts. The number of nuts should be equal to the number of bolts. So, these are the indifference curves for perfect complements.

Once we have the indifference curves and the budget constraint, we can now start to talk about the consumer's optimum. Of all the points that are there on the budget constraint and of all the points that are there on an indifference curve which is the point that the consumer actually suggests actually opts for.

So, the consumer's optimum is given by the point on the budget constraint that lies on the highest indifference curve. It is the point on the budget constraint. So, in this red line is the budget constraint. The consumer's optimum is a point on this line, it is not a point above or below this line and this point should be the one that lies on the highest indifference curve because we have seen before that a higher indifference curve is preferred to a lower indifference curve because people want to have more consumption.

In this case the higher indifference curve is preferred and the point on the budget constraint line that is on the highest indifference curve gives the consumer's optimum. This is the point that the consumer would choose if he or she were doing rational thinking. Because this is the point that gives the maximum amount of satisfaction given the budget constraint because what is happening here is that for points above the budget constraint.

So, any point on this indifference curve is not selected because the consumer does not have sufficient budget. And if the consumer selected some point on this curve, then she is left with a certain amount of money which could be spent on having more of both the goods which would mean that the consumer would move towards these indifference curves.

For every curve that is to the left of the indifferent slide, the consumer tries to move towards the right, but for an indifference curve that is away from the budget constraint line then this becomes an impossible combination given the budget constraint. The optimal point is given by the point on the highest indifference curve that is touching the budget constraint.

Here we can talk about two kinds of goods, one is known as a normal good. A normal good is one for which an increase in income increases the quantity demanded. So, what we are talking about here is that if the consumer is having more money, what will the consumer do? If the income increases will the consumer have more of the good or will he or she have less of the good.

There are things that are known as the normal goods; normal goods are everyday used goods that we have a large value for. Now, if the consumer has more income then more is the quantity demanded for this particular budget. That is what we are saying is that the income is represented by the budget constraint.

If we move from this lower budget constraint to a higher budget constraint and if these are indifference curves for good 1 and good 2 so, here we are observing that at this lower budget constraint. This was the optimum point at a higher budget constraint, this is the optimum point and at this point the consumer is having more of good 2 and the consumer is having more of good 1. Both good 1 and good 2 are normal goods because with an increase in income with an increase in

income, the quantity demanded has increased. If we draw these lines and if we say that this is point 1 and this is point 2. Then when the consumer is shifting from this lower income to the higher income, then the consumer is having more of good 2 and is also having more of good 1. So, these goods are normal goods. There are certain other goods that are known as inferior goods: a good for which an increase in income reduces the quantity demanded - things such as bus rides. What is an inferior good? Suppose you have less income in that case, you will prefer to go by a bus, but when your income increases then probably you will think that no instead of going by a bus, I can afford much and so, I should take a taxi - I should take a cab. In that case your demand for bus rides will go down. So, even though you are having more income, you are asking for less of this good less of bus rides. So, bus ride is an inferior good because with an increase in income less is the quantity that is demanded.

We can represent it by these curves. These are the two budget constraints, the earlier low income budget constraint and now the higher income budget constraint. Now what is happening is that in the lower income budget constraint, the optimum point was this. This is the point on the highest indifference curve. For the high income budget constraint, the optimum is given by this point. Now if we move from this point 1 to this point 2 what we are observing is that now less of bus rides are wanted and more taxi rides are wanted

In this case the taxi ride is a normal good because with an increase in income, more is the quantity demanded. But bus ride is an inferior good because with an increase in income less is the quantity that is demanded. So, this is an inferior good.

In this context we can talk about income and substitution effects. Income effect is the change in consumption that results when a price change moves the consumer to a higher or a lower indifference curve. When we talk about these changes, these changes can occur in two ways. One is that you can have an increase in income.

In that case you will move from one budget constraint to another budget constraint, but there is also another option that one of the goods or all the goods become cheaper. Now whether you get double income or the price of everything is halved it means one and the same thing.

When we talk about the income effect it is the change in consumption that results when a price change moves the consumer to a higher or a lower indifference curve. In this case when you talk about the income effect, the income is not increasing. But there is a price change that is leading the consumer to a higher or a lower indifference curve. And we can also talk about the substitution effect which is the change in consumption that results when a price change moves the consumer along a given indifference curve to a point with a new marginal rate of substitution.

In the case of a substitution effect, we move along the same indifference curve to a point with a new marginal rate of substitution. What we are saying here is that when we look at the indifference curves, the marginal rate of substitution here is different; here it is different and here it is also different.

In the case of a substitution effect, the consumer moves along an indifference curve to a point with a different marginal rate of substitution. And within both of these cases it is a price change that is moving the consumer along a curve or to a different curve and we can look at it with the example of again our samosa industry.

Now, here the case is the price of samosa falls. There is a price change that is happening. Now this price change can lead to an income effect or a substitution effect. Let us understand how. Now the price of samosa has fallen and so, the effective income increases because with the same amount of money now you can have more of the good. The samosa rate has fallen and so, you can now have more of the samosas, but you can also have more of lassi.

Because suppose earlier you were having earlier say, you were having 10 samosas and 3 lassis. Now the price of samosas has become half. In this case you can have 20 samosas and 3 lassi. But you can also do one other thing; you can also say that ok the price of samosa has fallen, but I only want 10 samosas, I do not want 20 samosas.

In this case, I will have 10 samosas. And because the price has fallen so, now, I am able to have or afford more lassis. In place of having 3 lassis probably I will have 5 lassis. Now this is the impact that we are studying. If the price of one good has fallen, then the effective income has increased because the same income here has not changed. But with the same income, now you can have more of the samosas or you can have more of the lassis or you can have some other combination.

Let us say that you can also have 15 samosas and 4 lassis. With the same income, now your effective income has gone up. You can have more of good 1 or you can have more of good 2 or you can have more of both the goods that is an income effect. Because of the income effect the effective income increases and. The consumer can now buy more samosas or the consumer can buy more lassis. This is the income effect. In this case the consumer is moving to a different indifference curve.

In the case of a substitution effect, your thought process goes like this. The price of samosa has fallen and so, now, samosa is relatively cheaper. So, let me have more samosas, which is what we are showing here because the price of samosas has fallen. So, let me have more of the samosas.

Let me have 20 samosas. So, that is a substitution effect or your thought process can be that now lassi is relatively expensive and so, I should have less amount of lassi because here we are talking about samosa and lassi. If the price of samosa has fallen, effectively it means that now the lassi is more expensive as compared to the samosas.

Earlier if, say, the samosa was 5 rupees and lassi was 10 rupees so, in this case lassi was equivalent to 2 samosas. But now what has happened is that the price of samosa has fallen. So, now, samosa is available for 2 and a half rupees, but lassi is available for 10 rupees as before. So, now, lassi is worth 4 samosas now if your currency was that of samosas, so you will say that ok, now the lassi has become more expensive because in place of paying 2 samosas for a lassi, now I have to pay for 4 samosas. Now if lassi has become more expensive, what will be your ah action? Probably you will want to consume less of lassi because it has become more expensive and this is what we are showing here. Lassi is relatively expensive and so, the consumer now buys less lassi whereas, in the case of substitution in the substitution effect the samosa has become relatively cheaper and so, the consumer buys more samosas. Now, what is the net result? The income effect says that more samosas should be bought. The substitution effect says more samosas should be bought and so, more samosas will probably be bought.

But in the case of lassi the income effect permits the consumer to have more lassi, the substitution effect says that the consumer should have less lassi and so, here the result will probably be ambiguous. So, the lassi bought may be more or less than normal. So, this is the income and substitution effect.

Because your one good has become cheaper, so, now you have shifted from this budget constraint to this budget constraint. So, now, you can have a situation where more or less of the goods can be had and with this, we can talk about the law of demand; reduction in price increases the quantity demanded.

This is what we had seen here. In the case of samosas, reduction in price leads to more samosas that are bought, that is, reduction in price increases the quantity demanded. We can represent it by these curves. This is the first budget constraint, this is the second budget constraint.

In the second budget constraint, the good 1 has become cheaper and so, now the consumer can have more on this budget. This is the earlier indifference curve and this is the optimum that was chosen, this is the new indifference and this is a higher indifference curve.

So, the consumer has moved from a lower indifference curve to a higher indifference curve and the optimum point has shifted from this point to this point. Now when the consumer moves from this point to this point, more of the good one is being demanded which means that we can observe the law of demand reduction in price increases the quantity that is demanded and we can explain it using the income and substitution effects.

But then this law of demand is not always followed. There are certain goods for which a reduction in price may also reduce the quantity demanded and good examples are Veblen goods and Giffen goods. Veblen goods are luxury goods whose demand increases with the price, for example luxury cars. Now luxury cars are an expression of the wealth of people. So, people want to have a luxury car to show off that they have a very huge amount of weight.

What will happen if the price of a luxury car goes down? When the price of a luxury car goes down, then it is no longer an expression of the wealth of the people. When it is no longer an expression of wealth, then people would want to have less of those luxury cars whose prices have fallen because they were buying a luxury car primarily because it was costing high, so that everybody came to know that ok this person is having this expensive car and so, this person must be having a great amount of money. But if the price has gone down, then it is not serving that purpose. So, these are Veblen goods, luxury goods whose demand increases with price or when the price reduces the demand also reduces another category is Giffen goods.

So, Veblen goods are luxury goods, Giffen goods are inferior goods whose demand increases with the price, for example potatoes. What we are saying here is that suppose we are looking at two items, potato and meat. Now potato is a relatively cheaper item, but potatoes also form the bulk of food requirements of people, meat is more expensive and meat is a source of protein.

But a person needs to have a certain amount of food to survive. Meat can be considered to be a luxury, but potato or a starchy food. In this case it is a necessity. Now what happens when the price of potatoes increases? Now in this case we are showing an increase in price. So, the earlier budget curve, the earlier budget constraint curve was this the blue one. Now the price has increased and so, less number of potatoes can be had for the same income.

Earlier the person was able to buy these many potatoes, but now the price has increased and so, the person can only buy these many potatoes. This is showing an increase in the price of the potatoes. So, now, less number of particles can be had. Now earlier this indifference curve was chosen and this was the optimum point. Now this indifference curve is being chosen and this is the optimal point.

What is happening here is that with an increase in price the effective income of people is going down with a fall in effective income and because everybody needs to satisfy their hunger, they will want to have more of the cheaper goods. And in this case the cheaper good between potato and meat is potato.

With less effective income people will want to have the cheaper goods to satisfy their hunger and so, now, people will demand more of the potatoes which is what we are observing here. Earlier this quantity of potatoes was being demanded so, the earlier demand was this the new demand is this. There is an increase in the demand for potatoes. So, this is a Giffen good.

So, the salient points in consumer choice is that it is the branch of microeconomics that analyzes how consumers maximize the desirability of their consumption and people are trying to maximize the desirability. And this desired variability is represented by the indifference curves and the consumption is limited by the budget constraint.

What does that tell us? One is that because people want to maximize the desirability of consumption. If we can make environmentally friendly options more desirable probably through education or awareness or advertisement, then we can shift people towards those options. So, we need to make environmentally friendly options more desirable.

But when we do that, then we have to ensure that even those environmentally friendly options are within the budget constraints because the consumption is always limited by the budget constraint. And so, if the cost increases too much then probably the consumers will not go for the environmentally friendly option.

So, these are two things that need to be kept in mind and when we talk about consumer choice we are making several assumptions. One is that operational behavior, the consumers are seeking to maximize their utility, preferences are complete, consumers fully understand his or her preferences, permitting unambiguous decisions.

Preferences are reflexive that is if good A and b are identical, then the consumer will be indifferent with regards to A or B, they are transitive it means that if A is preferred over B; B is preferred over C then A must be preferred over C. Preferences exhibit non satiation which means that more is always better.

Now, this is not true in a number of cases as we have observed that when you are already full, then if you are given an extra roti to consume then probably that is not better for you. Indifference curves exhibit diminishing marginal rates of substitution resulting in the bow in the indifference curves and that goods are available in all quantities including parts.

These curves are continuous curves so they can show even parts of things. So, this is 10.5 apples. These are all different things, but an important thing is that the first thing is that people exhibit rational behavior. So, this is a rational model to explain the consumer choice, but then the thing is humans are not always rational which will bring us to the concept of behavioral economics

that we will analyze in the next lecture.

That is all for today. Thank you for your attention. Jai Hind!

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Module 11
Practical issues in Economics and Conservation
Lecture 2
Asymmetric information, Politics and Behavioural Economics

Namaste! We carry forward our discussion on the Practical Issues in Economics and Conservation and in this lecture, we shall have a look at Asymmetric information and Behavioural Economics. Now, when we talk about behavioural economics, it is prudent to recap what we have seen so far.

When we talked about consumer choice, we talked about a number of assumptions in the model. Now, these are the assumptions that we normally make whenever we are making any economic analysis because these assumptions simplify things. So, in an earlier lecture, we had looked at what a model is.

So, a model is a simplified depiction of reality. If you look at the reality, reality is very complicated and so, to make a sense of the reality to look at what are the underlying principles or laws of economics, we need to make certain assumptions and some of these assumptions include things like rational behaviour.

When we talked about rational behaviour, we said that consumers are always trying to seek to maximize their utility. And throughout this course, we have said that the buyers try to maximize their circles; the sellers try to maximize their circles and that everybody is a rational behaviour, which means that everybody is using all sorts of information that they can have access to and are actively processing that information to come up with a decision.

But then, this assumption is not always true because in a number of cases, we do not have the information at all or if we have the information, then also, we do not have sufficient time to process that information and in certain cases, even if we have the time, we may not have the ability to process because the processing power of our brains is limited.

So, rational behaviour is an assumption that can be violated in certain points of time. Then, in the consumer choice model, we had said that preferences are complete and the consumer fully understands his or her preferences, which permits an unambiguous decision. But then, if you visit any restaurant, you will have the idea that in a number of cases, we cannot be in an unambiguous decision.

Because at times, we get confused; at times, we start to think - 'ok, should I have a mango ice cream or should I have a pineapple ice cream'; whereas, when we were talking about the model, we were saying that the preferences are complete and the consumer fully understands their pref-

erences. But that is not always the case. We said that preferences are reflexive. If goods A and B are identical, the consumer will be indifferent with regard to A and B.

However, in certain cases, people do attach an emotional sense to things and so, even if two things are identical, people might want to prefer one and not prefer the other one. We said that preferences are transitive. If A is preferred over B, B is preferred over C, then A must be preferred over C; but this again is not always true. We said that preferences exhibit a non-satiation, which means that more is always better; but then that again is not true in a number of cases.

For instance, if you are given an option to eat ice cream, you cannot just go on eating ice cream. There will be a point, where you will say- 'oh I am full now, I cannot have any more', but then when we were making the model, we were saying that more is always better. There are a number of cases in which our assumptions do not always hold true.

We also said that indifference curves exhibit diminishing marginal returns of substitute, marginal rates of substitution resulting in a bow. This is generally true, but then goods are available in all quantities including parts, this is not always true. But the bottom line is most of these assumptions do not apply in the real world.

How do people make decisions in the real world is the next question. We began with a simplified understanding of economics by making use of models to simplify the reality; but then, we also need to understand, what are the lacunas in our simplified models; how are they different from the real world and how do people in the real world make their decisions and we will explore this by using an example.

In an earlier lecture, we had looked at the production function. The production function tells that the output per hour when the number of workers increases, it goes on increasing; but then it starts to reach a plateau. The output does not just go on increasing, it will reach a plateau after a while. And so, if you have any more workers, then the marginal productivity of those workers will be less.

But then, if we concentrate on this section, is this always true? If you have 1 or 2 labourers, can you be assured of this output per hour or is there something else that you need to be concerned about. Let us say that in this firm, 2 labourers were hired. Will these 2 labourers give this output at all times or is there something else that we need to look at.

This is important because this is the basis of the understanding of the marginal product. Marginal product of labour as we had seen is the increase in the amount of output from additional units of labour. We had seen that the marginal product of labour, it goes on decreasing, which is another way of explaining the production curve.

In this context, we had said that there is this law of diminishing marginal product, which says that the property whereby the marginal product of an input declines as the quantity of the input increases because of crowding, insufficient access to equipment, chit-chats and so on. But is it possible that even when we are having just 1 or 2 labourers, they are not putting up their best? Now, we will see this is true in a number of cases.

We have used this property of diminishing marginal product to compute the value of the marginal product, which is the marginal product of an input times the price of the output. And here, we are seeing the value of the marginal product of labour and we saw that this is also going

down.

Because in the case of a fixed price, this will go down; so, the curve will look very similar to that of the marginal product. So, the value of the marginal product looks very similar to the marginal product. And we had used this to find out what is the profit maximizing quantity of workers that we should be hiring in a firm?

We have said that the profit maximizing quantity is given by this point, where the value of the marginal product of labour intersects with the wage rate and this value in this case the 4 labourers is the number of workers that the factory should be hiring. The question is does this hold true in the real world?

Because in the real world, workers often do not perform when they are left unsupervised. So, in this case, we are talking about 4 workers that should be hired to make the product. But in the real world, what we observe is that we do not only need these 4 workers, but we probably also need a supervisor and probably, also a supervisor to look after or supervise the supervisor.

Why is that so? So, this is because of things such as moral hazard. Moral hazard is "the tendency of a person, who is imperfectly monitored to engage in dishonest or otherwise undesirable behaviour". It is the tendency of a person and a person who is imperfectly monitored.

When we were making these models, we never talked about monitoring. So, this is something that we had left out throughout our understanding of economics, because we were taking people to be rational beings, we were taking everybody to be honest people. But in the real world, things are a bit different; sometimes things are very different because of things like moral hazard.

If people are not perfectly monitored, then it is possible that they will engage in dishonest or otherwise, undesirable behaviour. In other words, what we are saying here is that even when you have these 2 workers and in theory, they should be giving out this output of 90 units of products in an hour. In a number of cases, if they are not properly supervised, they will not make this.

There will be a number of situations in which workers might try to steal or workers may just spend their time or waste their time and do nothing. And when a worker does that? That is not because of economics because the worker would or if we consider that the worker is a rational person making rational decisions, then in that case, this person should not loiter away his or her time. Because time is money.

The time that is spent on loitering could perhaps be spent on a more productive thing. And we all have a dearth of time in our lives, we all have a particular life expectancy. So, any time that we waste is a time that we are losing out of our life. It is a loss. Now, a rational person would never lose his or her time, would never waste his or her time.

But in the real world, we find that quite a number of people waste their time and this may result in things such as moral hazard. Now, when we are talking about moral hazard, we are trying to bring in the behaviour of people into our understanding. So, this is behaviour and economy.

We are not just talking about a mathematical model of economics or a scientific model of economics, we are also taking into account what is the behaviour of people? So, moral hazard is the tendency of a person, who is imperfectly monitored to engage in dishonest or otherwise undesirable behaviour.

Why do people engage in such behaviour? This is because the worker knows more about how

much work he or she is putting in, than his employer. Which means that, if the worker was to put up an effort and bring out 50 items of product per hour and if the worker is not doing that, if the worker is wasting away his time, in that case if the monitoring is not perfect or the monitoring is inadequate; then, the employer would not know by how much amount the the worker has shrugged in his responsibility.

Now, this is the information that the worker has. This is not information that the employer has. Why? Because if the output is less, the worker can always say- 'oh sir, the machine was not working or sir, there was a power cut'. Now, if the supervisor is not there, if the owner of the firm is not doing an adequate amount of monitoring, if he does not have access to the electricity logs or does not have a CCTV camera put in, then the owner might just not know what has happened.

And in such cases, the owner will have to take whatever the worker is saying at the face value. If the worker says- 'oh sir, I was working very hard, but what to do, this machine was not working'. The owner will have to take that in good humour; but the worker actually knows whether it was the machine that was not working or whether he was just passing away his time.

This is information that is with the worker only, it is not there with the owner or the supervisor. And this permits the worker to engage into dishonest or undesirable behaviours. So, the primary cause is that the worker knows much more about how much work he or she is putting in, than the employer.

The uninformed party, that is the employer would like to know, but the informed party or the employee may have an incentive to conceal the information. Why? Because if the owner comes to know that this particular worker is a lazy person, he does not work properly, then this worker may get fired. So, in this case, it is in the best interest of the worker to hide this information and he will do all sorts of things to hide this information.

This is a moral hazard and moral hazard is occurring because of asymmetric information. "A difference in the access to knowledge that is relevant to an interaction". Asymmetric information is the difference in access to knowledge, which means that one person has more knowledge or more access to knowledge and another person or another party has less access to knowledge or has less information less knowledge. And what sort of knowledge?

A knowledge that is relevant to an interaction. That is, in the case of things such as the principal agent relationship, which occurs between an employer and an employee. The relevant information here is how much amount of effort the worker or the employee or the employee is actually putting up. Now, this is a relevant information because this can be used to find out how much amount of wage should be given to this person; does this person deserve an increment or does this person ah deserve a punishment.

Now, this is very relevant information. But then one party, the employee himself, has more access to this information, because he knows how much effort he is putting up and how much time he is wasting. But the second party in this interaction is the relationship between the employer and the employee, so the second party which is the employer does not have access to this information and this results in an asymmetric information.

That is, one party has more information; the second party has less information. And whenever

we have a situation of asymmetric information, we start to observe problems. Problems such as moral hazard or problems; such as adverse selection: a situation where a buyer is at a risk of being sold goods of low quality; such as a used car market.

Now, if somebody goes to a used car market to buy a car, then the sales person in that used car market has much more information about the car that he is selling than the person who has gone to buy the car. Now, whenever somebody goes to buy a car, this person will not spend say ages to find out each and everything about the particular vehicle. Now, some things may be obvious, but some things might not be that obvious.

Perhaps there is some malfunction in the vehicle; but the sales person knows about this information that there is a malfunction in this vehicle in such and such a portion. But then, the buyer or the prospective buyer, who has gone to see this vehicle does not know that and so, this buyer is at an adverse situation, when it comes to the information. Here again, there is an information asymmetry.

The salesperson knows more, the sales person has a greater amount of information; the prospective buyer has a lesser amount of information. So, there is an information asymmetry. Now, this information asymmetry may result in an adverse selection, which means that the buyer may choose not the best vehicle; but may choose an adverse vehicle, that is not that good.

And the buyer is not choosing an adverse vehicle because he wants to have a not so good car. But the buyer has got less options because he has a dearth of information. Even if he wanted to check everything, he would not have sufficient time or would not have sufficient expertise to check each and every part of the vehicle.

So, things such as these are related to asymmetric information and may result in adverse selection; a situation where a buyer is at a risk of being sold goods of low quality. And when we have these situations in a number of cases, they increase the cost of the transaction. Now, remember that when we talked about the surplus, when we talked about the total surplus, we had said that the cost should be low.

Because when the costs are low, then the welfare is maximized, the surplus is maximized. But the problem with Edward with asymmetric information is that it increases cost because the uninformed party has to put in effort to get the information out. Such as go for better monitoring, install a CCTV camera, employ more number of supervisors.

Now, supervisors are something that we had not considered, when we were looking at the micro-economics of the firm. Because we just said that ok one person is giving out so much output and so, so many people must be hired for it. But then, to make a way for this point that the person might not be working to their fullest or maybe engaging in an undesirable behaviour, the employer might have to install a CCTV camera.

Now, when the employer installs a CCTV camera, then it increases the cost of production because somebody will have to pay for this CCTV camera installation and run. And so, these costs will be recuperated from the sale of the thing because this is an addition or an additional input that the owner has to make.

Similarly, the owner may employ a few supervisors. Now, the salary of those supervisors is a cost that is being added to the cost of production and so, the surplus of the producer would go

down because his costs are increased. Another option is to pay above equilibrium wages such as efficiency wages.

So, paying of above equilibrium wages is another way to solve the moral hazard; but then, this also increases the cost or the owner might say that, 'ok, we will go with for a delayed payment', which means that ah the owner might say that, 'ok we will give you ah a year-end bonus'.

This year-end bonus would ensure that the person has got more to lose. If the employee does not work that hard, then the employee might not know currently; but then, at the end of the year, the owner might always say that, 'this year, you did not work hard and so, I am not giving you the year end bonus'.

These are all ways to counter the problem, but all of these are also increasing the cost, they are also increasing the complexity. Similarly, we have measures to control the adverse selection; things such as avoiding the used car market. But then, if the market is avoided, it means that the market is being shut.

The market is not working and so, the surplus that this market could have provided is lost. That increases our deadweight cost to society because the market is not working. Another thing is that the prospective buyer might try to get the vehicle inspected by a third-party and especially, a third-party that is a prominent manufacturer.

Now, in this case also, the third-party might give out the correct information; but then there is a cost involved. The prospective buyer will have to pay to the third-party to get the vehicle inspected. So, all of these measures are increasing the cost, the cost of transaction and when the cost of transaction increases, it means that the surplus reduces.

In this context, we can always talk about signalling and screening. These are two ways to counter the problem of asymmetric information. Signalling, we have seen it before as well. It is "an action taken by an informed party to reveal private information to an uninformed party".

The difference between signalling and screening is that signalling is an action taken by an informed party, screening is an action taken by an uninformed party. And in both the cases, the motive is the same to get the private information out to the uninformed party or to induce the informed party to reveal the information.

In both the cases, the aim is to take the information out of the informed party and give it to the uninformed party so that this situation of asymmetric information gets solved. Now, signalling because it is done by the informed party, it can take forms of advertisement, good grades on the CV and so on.

When you make your CV and when you have good grades on your CV and when you give it to an employer, in that case you are giving a signal to the employer that yes you can have a look at my CV and I have had so good so many good grades; it means that I am a hard worker, I am a punctual person, I am an honest person.

A person who is not hard working will not be having those good grades and so, this acts as a very good signal. We had also seen that there are two characteristics of a good signal; 1 is that it should be costly to prevent rampant usage and it should cost less for the high-quality product and more for the low-quality product.

And which is why good grades become a very good signal, because a person who is not that hard

working will find it very difficult to have good grades; whereas, a person who is hard working will find it very easy to have good grades. So, it is costlier for a not hard-working person to have this good grade on his CV to use as a signal; whereas, it is less costly for the hard worker to have good grades on his CV and use them as a signal.

Now, because of the differential costing that is involved, the differential amount of effort that is involved, grades become very good signals. In the case of screening, it is "an action taken by an uninformed party to induce an informed party to reveal the information". In this case, the uninformed party is doing something and that something is to induce the uninformed party to give out information about itself. So, I am just asking for a third-party check of a vehicle.

Now, if somebody goes to a used vehicle market, finds a vehicle that he likes and then asks that he wants to go for a third-party checking of this vehicle. Now, if the salesman says 'no, no, no sir; you do not require a third-party check, do not you trust me' or things like that, then it gives out information that there is something wrong with this vehicle.

Because of which the salesman does not want to go for a third-party check; whereas, if the sales person says, 'ok sir, you can call any mechanic and you can have a third-party check', then that would mean that the salesperson is much more honest with you or with the buyer. Now, another example is the medical examination of a person, who is coming for insurance.

When somebody comes to get medical insurance or life insurance, the insurance company generally asks that person to go for a medical examination, get a medical certificate about, how fit you are? So that the person, if he or she is having any underlying diseases that should come up and that would influence the rates at which the insurance will be provided to the person.

If somebody is healthy, then ah this person would not have any hesitation to go for a medical examination; but if the person is having an underlying disease that he or she is trying to hide, so in that case, when the insurance company says that you should go for a medical examination, this person would say. 'no, no, no, why should I go for that; do not you see that I am a healthy person'.

If somebody tries to say that, 'no I do not want to do this, I do not want to go for a third-party examination or a medical examination', then this party is giving out an information because if everything was right, then why would this party ah want to avoid the examination and so, this becomes a form of screening. So, screening is an action that is taken by an uninformed party.

In this case, the buyer who is going into the used car market or the insurance company because they do not have the information and this action is to induce an informed party to reveal the information. Now, all these things come under the habit of behavioural economics. Behavioural economics is the subfield of economics that integrates the insights of psychology.

What we are doing in the case of behavioural economics is that we have certain insights from psychology about how people think, how people make decisions and we are incorporating those insights into our models to understand how people make decisions. When that is done, we say that we are doing behavioural economics and some psychological insights, that are incorporated are things like people are not always rational.

In our classical economics, we had assumed that people are always rational; but in this case, we know from psychology that people are not always rational. So, we have to make space for that.

Instead of going for maximization, they go for decisions that are 'good enough'.

That is, people do not try to maximize their welfare, they try to have a welfare that is good enough for them. So, till now, we had been concentrating on the maximization of welfare, maximization of surplus; but that is not something that always happens. Most of the time, people want to have a value that is good enough for them. The Reason is people are overconfident.

So, people do not want to go with lots of computations, to come up with the maximum; but they would say ok this is the amount that is good enough or just do this and you will get a good result. Because there are people who are over confident, they do not want to go into the computations because of their confidence or people give much weightage to a small number of vivid observations.

If there is a person who has observed that a particular vehicle did not perform that well. Perhaps, it was a friend's vehicle and this vehicle was not working that well. Now, this is very vivid information because this person has observed this vehicle from close quarters and the person might give an over emphasis to this piece of information.

When that happens, people might not go for the maximization of their welfare; but they would want to say that, 'ok this ah this vehicle I know that this vehicle it does not work well and so, I am not going to consider this vehicle at all'. Even though it is possible that it was just an isolated case, it was an isolated example and, on average, this vehicle performs very well; but still people go for decisions like that. People are reluctant to change their minds.

So, if somebody goes and tells a factory owner that, 'ok you are working in a region, where your marginal cost is greater than the marginal revenue; you need to cut down on production'. The person might react vehemently. The person might say, 'oh no, who are you to tell me' because people are reluctant to change their minds. People assume that whatever they are doing is the correct thing to do; people forget.

When we were talking about rationality, we were saying that people are taking all sorts of information and they are doing all the processing that is possible to come up with a rational decision. But then when people forget, then it is possible that some of the earlier inputs are not just taken into consideration at all. People are at times impulsive or confused or emotional.

So, people might just say that, 'ok, so such and such a person had told me that this is the right course and ah this person has always been guiding me very well. And so, I will just follow it. I will not do any sort of computation because I am very emotional, when it comes to the advice that is given by this person' or at times people make decisions when they are in anger, when they are feeling depressed.

In all these different situations people might not be in the best state to do a rational computation. People at times are impulsive, confused. When they are confused, they might not make rational decisions. People are often short sighted, they look for quick benefits, they look for ways to avoid the harms that are there in the near future. So, if there is a person, who is ah say smoking a lot.

So, this person knows that smoking is bad for health, smoking is injurious for health; but still this person will not be able to quit because this person is looking only for the short-term benefits. In the short term, it gives a very good urge. It gives a very great amount of energy; people feel ener-

getic when they have a cigarette.

In the long run, well, it does have its health consequences; but then people take decisions on the short-term basis because they are often short sighted. Another insight is that people care about fairness. Now, in a number of situations, we have observed that we can compute what is the wage that should be given to a person.

We can look at the supply of workers, we can look at the demand for workers and compute what is the equilibrium wage that should be provided to a worker. But then, people might even think, 'oh no, this is too less. How will this person survive on such a less amount of money' and so, people might want to give a higher wage.

This is not because people are doing a profit maximization, but because people are looking at fairness; is it fair enough to give such a small amount of wage to this person? People are inconsistent over time. They prefer instant gratification over sacrifice such as not saving enough for retirement.

In this case, people when they are getting money, when they are getting their wages, they can use it for an instant gratification to buy something or they can put it into a retirement corpus. But most of the people put a very small amount of money into their retirement corpus.

Even though they know that a time will come, when they will not be earning anything because they will be retired and at that time, these savings will be the largest source of support for them. But still, they do not do that. They do not put money into the retirement corpus.

This is because people prefer instant gratification; 'what can I have now because retirement period is after a very long period of time, so we will see what will happen at that time' is the sort of thought that people will have. So, people are inconsistent over time.

And the rationality is bounded which means that when we talk about rationality, when people are even doing all sorts of computations, they are trying to get all sorts of information, even then there is a limit to rationality. So, even when people are trying to do everything to get to a rational decision, they will not be able to or they might not be able to.

For example, how many times have you computed utility to rigorously maximize utility? Hardly anybody does such a sort of computation. Now, bounded rationality is "the theory that people can understand only a limited amount of information within a limited amount of time, and for this reason, they do not always make the best choices, especially in complicated situations", that is rationality is bounded by limited thinking capability.

Well, our brains are not evolved to make mathematical decisions in a majority of cases. Our brains are evolved to get food, to protect ourselves from predators, to get shelter and so on. Our brains are not evolved to do computations about what should be the surplus and so, we might have a limited cognitive capability to process the information.

So, even if we have all the information, we will not be able to process it. And especially, when the time is limited because a number of decisions have to be made in a short period of time and in that short period of time, it is possible that our processing capabilities are overwhelmed.

Rationality is also bounded by limited information because in certain cases, people are able to do the computation; but then, they do not have the raw materials, they do not have the raw data on which to base the computation. If you want to go to say Dehradun or you want to go to Siliguri

to spend your vacation, if you want to make this decision, you would want ah you would probably require all sorts of information that is there about Dehradun and Siliguri, but then you might not have access to that information. In a number of cases, people just make a decision out of their hunch because they have limited information and also, people have a limited time.

So, when time is limited, that can also limit rationality. And to solve the issue of bounded rationality, people make use of heuristics. Now, heuristics are rules of thumb. They are simple strategies or mental processes. The key point here is simple. A heuristic is something that is simple that is used to quickly form judgments, make decisions, and find solutions to complex problems. When we are using heuristics - and we use heuristics a lot. Heuristics are rules of thumb that for such a question, we should approach through such a manner. So, these are simple strategies or simple mental processes, things such as divide and rule. When you come up with a very big sort of a problem, what you do is you divide the problem into smaller bits and you try to solve each and every small bit one by one.

This sort of a decision-making process, this sort of a strategy that you take to solve a complex problem by dividing it into a number of smaller problems, this is heuristics. Because this is a simple strategy, this is a simple mental process used to quickly form judgments or make decisions or find solutions. Now, here the key point is quickly. They are used because they are fast and in a number of situations, we do not have sufficient time to make a decision.

Heuristics help us. Example, things like affect heuristic. Affect is emotion. So, affect heuristic is a heuristic or a rule of thumb that is based on emotions. It is a "mental shortcut using emotion or gut feeling to influence a decision". So, you are not doing the computation, you are just using your emotion or the gut feeling to make a decision such as a person buying an SUV, just because he or she feels an attachment due to its look.

People use this because they might not have sufficient information or processing capability or time to make a rational decision. So, while a rational person would have done a thorough cost benefit analysis; but a person who is making a decision based on the emotion or the gut feeling, does not do this cost benefit analysis, but just buys whatever he or she feels an attachment due. This is an affect heuristics.

Another example is availability heuristic. It is a rule of thumb or a shortcut based on availability of information. A "mental shortcut using ease with which examples come to the mind to influence the decision". Example, a person not buying a particular car just because he or she has a friend with this model and the friend's car gives problems. A rational person would have done a thorough cost-benefit analysis, for this could be just an isolated example.

Another example is the effort heuristic; how much amount of effort do you put into doing something. It is a "mental shortcut using perceived amount of effort to determine the worth of something" and an example is that 100 rupees earned is perceived to have much more value than 100 rupees found, or gifted and spending decisions reflect this perception.

A rational person would have determined that these are perfect substitutes. What is happening here is that if you are earning something, if you are putting an effort into doing something, you put a larger value on it; but if you were given this thing, the same thing by somebody or you found it lying somewhere, then you do not put that higher value to it.

For example, a 100 rupees that is earned is perceived to have a much greater amount of emotional value because of which people will try to hold on to this 100 rupees, they will not be spending it that easily; they will be spent thrifitly; whereas, a 100 rupees that has been gifted by somebody will not be having that high and emotional value. So, people will spend it much more easily.

They will not do a very large amount of rational decision making when it comes to that 100 rupees that is gifted. Now, this is an example of an effort heuristic. Another example of heuristics or heuristic decision making is escalation of commitment. It is a "mental shortcut justifying increased investment in a decision because the prior investment was made".

Now, here again people are not doing rational decision making, they are just using a mental shortcut to justify increased investment in a decision. Example is a person buying a used car for 2,40,000 rupees, spending 40,000 on it for repairs and still allotting 50,000 rupees more for repairs, when a new car could be bought for 3,00,000 rupees.

Now, in this case, the person bought this car for 2,40,000 thinking that it is less than 3,00,000; the person has already spent 40,000 rupees. So, now, the amount that has been spent is 2,80,000. But now, the person is still allotting 50,000 rupees more for the repairs. So, if this amount is spent, the total amount will be 30,000 more than the price of a new car.

But still the person is justifying this investment because a prior investment was already made. So, the person would think that because I have already spent 2,80,000 rupees. So, 50,000 more is not that high a price or that high an investment. Now, a rational person would have determined that the earlier investment is a sunk cost, which means that it is a cost that was incurred and cannot be recovered back.

So, when you are spending the next 50,000 rupees, you should think, 'oh should I spend this 50,000 rupees on a second hand car or should I just sell this vehicle off and buy a new car. Because at least in that case, I will not have to do this spending again and again and again, because a new car will not give me that amount of problems and even if some problem comes, it will come under warranty'. But you do not take that decision.

People just think that, 'ok because I have already spent 2,80,000 rupees, so let me spend just 50,000 rupees' whereas, they could have sold this earlier vehicle and got a new car. Now, this is an example of escalation of commitment heuristics. Now, in this case people are not doing the computation about what is best for them; but they are just thinking that because an earlier investment was made, we should do the next investment.

This is a shortcut. Now, remember that when we talk about shortcuts in certain cases they help; but in a large number of cases, they also harm us because they give us a solution that is fast that does not involve a lot of information processing, but that at times also does not give us the most efficient outcome. It does not maximize our surplus that could have been possible, if we went for rational decision making.

Another example is a familiarity heuristic. A "mental shortcut preferring familiarity over unknown". Example, a person buying a particular car just because he or she has had a car of this make at home during childhood. Now, a rational person would have done a thorough cost benefit analysis; but what a number of people do is that, 'ok my dad bought a car from this company. So,

I should also buy a car from this company because I am familiar with this car'.

Now, it is possible that with time, new technologies have come up and a car of some other company is now giving a much better safety, much better service, much better mileage than a car of the previous company. But still people take the car of the previous company because they know this car.

This is a familiarity heuristic. It allows for a quick decision making without a lot of computation, but being a shortcut, it does not give the most optimum results. And because of these bounded rationality and heuristics, we have cognitive biases. Cognitive bias is "a systematic pattern of deviation from the norm or rationality in judgment".

In all of these cases, what we are observing is that there is a deviation from the norm or rationality. That is, the optimum was something else; but because of our way of thinking, we chose something else. This is an example of cognitive biases. Cognition refers to the process of thinking. So, this is a bias in thinking, a systematic pattern of deviation from the norm or rationality in judgment.

Because of bounded rationality, we have evolved several cognitive biases, they distort our thinking process and lead to more irrational decision making. Now, in this case, we are asking the question that if people have these cognitive biases, what kinds of impacts do they have on the decision?

Now, this is something that is not inside the purview of classical economics; but here, we are making rules from our insights from psychology to understand how people are making decisions. Because remember that economics is the science of decision making. So, what are these cognitive biases? Confirmation bias: favouring information conforming to existing beliefs, and discounting evidence that does not conform to it.

Example, if A thinks that B is a bad person, he will only consider that information about B that shows him in a bad light, while ignoring or discounting the good traits. What happens in the case of confirmation bias is that we already have a preconceived notion about something and whenever we see something, whenever we get new information, we see the new information in the light of our preconceived notions.

A very good example in the case of conservation is that there are people, who think or who have this preconceived notion that we can either go for development or we can go for conservation. Now, if you tell these people that, no if you go for conservation, this will also help in your development.

A very good example is underpasses. So, if you construct underpasses, you will also make your roads much safer and people will also be able to drive on the road at much higher speeds because there is no risk of a wild animal getting on the road and hitting the vehicle.

Now, rationally, if you think about it, yes it makes quite a good sense because the cost that is involved in making an underpass is not that great. But then, people with this preconceived idea that no conservation is anti-development would just say, 'no, no, no, no, we are development people, we are not conservation people'. As if conservation and development are two very different things.

This is a confirmation bias. Whenever they see an information that through conservation, people

led to development that if in an area when a national park was built or constructed, the people in the locality had a very large jump in their median incomes. If they get, if they see such information, they will just discount it; they will just think, 'oh, this is one of them, this does not always happen'.

But if they get any information about conservation and especially that conservation that was not well executed, that led to some difficulties; then, they would always keep this in mind and say 'oh, this is why we should not do conservation'. So, this is a confirmation bias.

Favouring information conforming to the existing belief and discounting everything else. Another is halo effect; tendency for positive impressions in one area to positively influence one's opinion or feelings of one in other areas. Example Apple's iPod is good, so Apple should be good for other devices as well.

What is happening is that because somebody has a positive impression about something in one area, this person thinks that 'oh this is the thing that is true for every other thing as well'. A good example is that again if you talk about roads. Now, if some person saw that ok a road was built between two cities and that increased the welfare of the people because they were now able to move from city A to B and back in a much quicker manner.

Now, these people would think that no roads are good for people. Let us make roads everywhere; even if it is a national park, let us make a road inside it. In a number of cases, we can observe that there are roads inside national parks that nobody is using; but still there was some person who made this road because they thought that, 'ok roads are good for people, so let us make roads', that is the halo effect.

A positive thing in one aspect is taken to be a positive thing for everything else. Horn effect: tendency for a single negative trait to negatively influence one's opinion of feelings in other areas. A person is not wearing clothes properly, so the person must also be lazy. Well, it is possible that this person is just coming out of a train with a very long journey.

So, this person is not looking very sharp, but that does not mean that this person is lazy. But what people do is they just take one thing and put the same feeling to every other trait so, in the case of the horn effect, the tendency for a single negative trait to negatively influence one's opinion or feelings in other areas.

In the case of conservation, we have observed examples in which when a national park was built and there were say in a village of say 1000 of 100 families, 95 families wanted to move out. Because in any case who wants to live in the center of a jungle surrounded by animals.

So, everybody wants to be a part of the mainstream and whenever a national park is made, then people are given a very large sum of money as compensation to move on and we have ah this thing that ah moving out has to be voluntary. You cannot force anybody to move out. It is a voluntary decision that people made. Now, 95 ah families decided that they wanted to go out and they made use of this opportunity. But there were 5 families who for some reason wanted to stay inside.

Now, a person who is using the horn effect would just look at those 5 families and flash it on the media and say that, 'oh see, these are the 5 people and they wanted to live inside, but everybody has left them'. And so, conservation is bad, we should not be making any national parks. That is

a horn effect. This is again a cognitive bias. Because in this case, we are not looking at the benefits that the national park is providing to people.

We are not looking at those 95 people or 95 families who wanted to move out voluntarily and at least got this option through the construction of the national park. No, we just look at one negative thing and we spread that negativity everywhere, negativity everywhere. Another is fundamental attribution error: a tendency to differentiate situational and innate attributions for self and others.

That is, "if I came late, it is because of the heavy traffic" which means that if I am doing anything late, if I am not doing anything good, then it is because of the situation; it is not because of me. I am good; but the situation was bad. But "if he came late, it is because he is lazy." So, for other people, we say that if anything negative has happened, it is because those people are lazy people, those people do not work properly.

But if we are not doing something properly, we will say oh this is not because of me this is because of the situation. This is a fundamental attribution error, a cognitive bias. Priming: exposure to one stimulus influencing response to another stimulus, which may or may not be related. The look of a well-set restaurant enhances the taste of food.

Now, what is a well-set restaurant look, what to do with the taste of food? But then, this one stimulus influences the response to another stimulus. Affinity bias: bias towards people like ourselves or people with the same language or from the same region. We have observed that this is a major reason for discrimination in the labour market.

But still people do it. Self-serving bias: a tendency to claim more responsibility for success than for failures. "I topped because I worked hard; but then, if I failed it was because the examiner was biased". So, we are always self-serving. Framing effect: people decide based on whether the options are presented with positive or negative connotations.

"A treatment with 30 percent probability of saving lives" is preferred over "a treatment with 70 percent probability of death". Now, look at both of these, both of these mean the same thing; 30 percent survival is 70 percent death. But then, if you present it in a positive sense, then people like it more. This is the bias.

Hindsight bias: a tendency to perceive events that have happened as having more predictability than they actually had. So, in hindsight, people would say "he should have known that doing this would damage the machine". He should have known, but then they discount the fact that this person - had they known that it would destroy the machine - they would not have done that.

Because in hindsight, it is easy to see things; but in the foresight, it is difficult. Gambler's fallacy: a tendency to perceive that certain events occurred more frequently than normal in the near past, then they will occur less frequently than normal in the near future.

"I lost five times in a row, so now, I will win". Now, in such cases, people and in a number of cases, they lose out like anything. Because a gambler always thinks that, 'ok five times, I have not won, the sixth time, I will win; the sixth time when he again loses, he will think, oh I have lost for six times, in the seventh time, I will win' this is a cognitive bias.

Optimism bias: a tendency by persons to perceive that they will be spared from the negative events. So, people are very optimistic. "I won't suffer from a car crash, so I do not need to wear a

"seat belt" as if the person is something out of the world, then they would not suffer from a car crash. This is an optimism bias. Herd mentality: a tendency to perceive certain decisions to be correct, just because many people are making those decisions.

So, "everybody is buying this company's stock, so I should also buy"; everybody is buying a car of this particular make, so I should also buy. Now, when we look at all these sorts of psychological attributes to decision making, it also has an impact on economics and it also has an impact on conservation.

In a number of cases, if people just sat down for two minutes and thought about things rationally, things would improve. People would come to the conclusion that 'yes, we have to work for development and we have to work for conservation', but without rational thinking, what people do is whatever has been happening, let us do that only. When that happens, that leads to a number of wrong decisions.

This is something that needs to be kept in mind. Rationality is bounded and if you know that rationality is bounded, you will be working more towards ensuring that no you are not taking everything for granted, you are not working in a herd mentality that because everything, because everybody took this decision, so I should also make this decision. So, this is something that needs to be kept in mind.

That is all for today. Thank you for your attention. Jai Hind!

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Module 11
Practical issues in Economics and Conservation
Lecture 3
Valuation of natural resources

Namaste! We carry forward our discussion on the Practical Issues in Economics and Conservation. And in this lecture, we shall have a look at the valuation of Natural Resources. Now, natural resources are defined as those resources that exist without the action of humans.

What this means is that these resources are not man made resources; they exist naturally without the need for human beings such as the rainforest. Now, these resources can be threatened by human beings through over exploitation or through things such as pollution.

But for them to be maintained in a pristine state, no action from human beings is needed. So, these are the natural resources that exist without the action of humans. And natural resources can be divided into several categories. On the basis of origin, we have biotic resources and abiotic resources.

Now, bio means life. So, biotic resources are those that are coming from living matter such as timber. And we can also include things such as the wild animals under the biotic resources, or things such as the seaweeds or the corals. Now, all of these play a very important role in the maintenance of our planet earth.

Because they play a very big role in the modulation of the climatic cycles. And these resources that are living resources or derived from living things are known as biotic resources. Abiotic resources are those resources that come from nonliving matter such as iron ore. On the basis of the stage of development, natural resources are divided into potential resources, actual resources, the reserve resources and stock resources.

Potential resources are those resources that may be used in the future, for example oil that has not been drilled. So, these resources exist, but we are not using them, but we may use them in the near future or in the far future. So, these are potential resources. The resources that exist but that may be used in the future.

Actual resources are those resources that are currently being used. And generally they are used after surveying, quantification and qualification, such as timber from the forest. These are actual resources because we have done an exploration, we have done a quantification and qualification of these resources, and we are actually using those resources.

When we talk about oil that is being extracted from an oil well, that is also an actual resource. But if we know that there is oil somewhere, but we are not using it, but we can use it in the near

future whenever we require it, then we say that it will be a potential resource.

Potential versus actual depends on whether it is currently being used or it may be used in the future. Reserve resources are the part of actual resources that can be developed profitably in the future such as low concentration ores. So, when we talk about the actual resources we are actually using those resources.

But in the case of iron ore, there will be certain portions of iron ore that will be having a very high concentration of iron. And the current state of technology makes it possible to extract iron out of that iron, but there could also be certain other iron ores that are also getting extracted, but they do not have a high concentration of iron.

The current state of technology does not permit us to extract that iron ore in a profitable manner, but in the near future when the technology develops further we are going to use it. Now, these resources are actually being extracted. So, people when they are doing the mining, they will be extracting these iron ores and probably dumping it near the mine site itself.

These are known as the reserve resources because they are part of actual resources, we are actually taking them out, but we are not able to extract them profitably or use them profitably using the current technology and. We call them reserve resources that can be developed profitably in the future. We still have methods to use these resources, but they are not profitable currently.

The fourth category is stock resources. Those resources that have been surveyed, but we lack the technology to use them all together such as hydrogen for nuclear fusion. Now, we know that in the fusion reactions as happens in the stars or in our Sun, hydrogen is fused together to form helium.

Now, because we know that such a reaction exists and we have used this reaction in thermonuclear weapons, this is a resource that can also be used for the generation of electricity. If we could control nuclear fusion, we could use it in the generation of electricity, but currently we do not have the technology to do that.

Even though we know that we have plenty of hydrogen in the water in our oceans, we currently lack the technology to do this fusion reaction in a controlled manner. And so we will call them stock resources. These are resources and these resources have been surveyed. We know how much hydrogen we have, but we lack the technology to use them.

Similarly, on the basis of renewability, we have renewable resources and non-renewable resources. Renewable resources are those resources that can be replenished naturally such as sunlight. Now, what happens in the case of renewable resources is that the natural processes ensure that we will continuously get these renewable resources things such as forest.

Now, in the case of a forest, if the extraction is done in a sustainable manner, we do not do an over exploitation of the forest. What happens is that the trees will produce seeds, these seeds will fall down, they will germinate, and they will produce the next generation of trees. And so these are renewable resources that get replenished naturally.

On the other hand, we have certain non-renewable resources, those resources that either form slowly or do not form at all in the environment. So, the process is so slow that it is as good as that these resources are not being produced at all now things such as coal or petroleum. Now, it takes millions of years to produce coal or petroleum under conditions of high temperature and

pressure.

Now, the rate of the formation is so slow that if we use up the coal and petroleum that is with us, we will no longer have any more coal or petroleum. And so resources such as these are known as non-renewable resources. They are not renewing themselves naturally, they are not replenishing themselves. And so we have to be extra careful whenever we are using these resources.

When we talk about resources, we also do an economic valuation of resources which suppose you have a forest you may ask the question what is the value of this forest? When you do an analysis to find out the economic value of the forest meaning that ah how much is this forest worth, is it worth a few lakhs of rupees, is it worth a few crores of rupees or more?

When you do such a valuation, it is known as an economic valuation. You are putting a value to the forest and this is not a religious value or a social value, but you are putting a rupee value or a dollar value to the resource, so that is an economic valuation of resources.

We do economic valuation of resources primarily for three functions. One is to aid the cost benefit analysis when the natural resource is being diverted, for example a forest that is being diverted into mining. Now, these sorts of situations arise again and again, we have limited forests and the land over which the forests are standing can also be used for several other purposes like mining, or things like making a road, or things like even agriculture or making up residential areas or industrial areas.

Whenever we get a proposal like that, we need to do a cost benefit analysis which means that we ask the question that ok if this forest is getting diverted, and suppose we will divert it and form a mine, now when that happens what is the loss that we are incurring because once the mine has been developed, we no longer have the forest. Which is what we are seeing here is that you have a forest and the proposal is to divert it into a mine.

Now, suppose the forest is worth rupees 50 crores, and the mine is worth rupees 30 crores. Now, in such a case, once you have the mine, you no longer have the forest. So, you are giving up a thing that is worth 50 crores to get something that is worth only 30 crores. And so no rational person would say that we should be diverting such a forest. So, this cost benefit analysis is very important.

Once we know the value of the forest, in a number of cases the people who come up with the proposal to develop the mine, they would have done all sorts of computations about how much is the amount of ore that we are going to extract from it, and what is the market value of that ore.

They would even come up with things like ok how many man days of employment are we going to generate with this mine. But they will only be presenting their side of the picture, that is that the mine will develop so many days of employment and it will add so much rupees to the GDP.

But then when we look at the forest the forest in itself is also giving a number of advantages to society. It was giving a large number of things such as biodiversity benefits. It was controlling pollution; it was making the rivers flow; it was a storehouse of biodiversity.

And this biodiversity is very important whenever we get a new disease for instance because if there is a new disease, you have to look for a cure. And in a number of cases, we get cures from the secondary metabolites that are there in several plants. So, if you have the plants you can extract the secondary metabolites and probably in a short while also make them chemically.

But then to test these chemicals we need these chemicals. And these chemicals will only be there in the plants. So, a storehouse of biodiversity is important because we may use these bio resources in the near future or in the distant future. Now, when this forest is diverted into mine, all of these things and probably a lot more are gone.

There is no longer a tourism potential in this area because people want to visit forests to watch tigers, nobody wants to go to a mine and see how the mining is done. So, the tourism potential of a forest is very large, probably this tourism potential was also providing employment. Probably it was a potential resource but it is not an actual resource which means that if the forests are beautiful if they have wild animals like tigers, then these are potential resources. Maybe we could have developed them into a tigerism. But once you take this decision to convert them into a mine, then you no longer have the forest. And once you do not have the forest, it is not no longer an actual or a potential resource from the forest point of view.

So, we need to make these computations about what is the worth of the forest and what is the worth of this mine, and only then will we be able to make a correct decision. So, economic valuation is important to aid the cost benefit analysis when the natural resource is being diverted, for example a forest being diverted into mining.

It is also important to provide evidence to aid the habitat conservation policies by highlighting the economic value that is associated with conservation, for example watershed benefits. Now, the thing here is that the forests are very important to ensure that the rivers flow.

Now, what happens in the case of forest is that suppose you have mountains and there is a river that is flowing. Now, when it is the rainy season, when it rains, now in our country we have the rains only in very few months in a year. In most parts of our country, we get rains only in the monsoon season; in certain areas we also have winter rains, but that is all.

In most cases, we will not have rain in the month of March or in the month of April. Now, what happens is whenever you have the rainfall, the water that is falling down; if there are no trees, then this water will just flow over the surface of these hills and reach into the river. And whenever it is raining, then we will have a huge amount of water in the rivers which means that we will be having a flood like situation.

And when it is not raining, then there is no water that is getting into the rivers, and so we will have a situation of drought. Now, in such a scenario, when you have consistent floods and droughts, then that river is not very useful for human beings because we are not assured whether these rivers will be flowing or not.

What happens with the case of trees is that when you have trees on these mountains, then these trees act as stoppages for the water that is coming down in the form of rain. So, the rain droplet that falls on the tree canopy will be stored in the tree canopy for some period of time. And then slowly and steadily it will come down. That is, when you stand beneath a tree after it has rained, after the rain has stopped, you will find that some amount of water is coming down trickling down.

Now, that was the water that was intercepted by the leaves and was stored in the ah canopy itself. Then slowly and steadily what happens is that this water makes its way through the surface of the trunk. So, this is known as a stem flow. So, this is a stem flow. Which means that if you stand

beneath a tree after it has rained and if you touch the stem of the tree, you will find that it is wet because of all that water that was collecting in the canopy.

It is now slowly trickling through the stem of the tree, and then it is reaching to the ground. Now, once this water reaches to the ground surface that is the earth surface, now what does it find? It finds the roots. So, what is happening here is that you have this tree and this tree will also be having roots, and suppose this is the ground layer.

What is happening is that first of all the water was intercepted by the canopy. So, it was stored in the leaves, that is, on the surface of the leaves. Then slowly it starts to trickle down through the surface of the stem in the process of stem flow, and then it reaches into the ground because the roots have already made a hole in the ground.

And when this water has entered into the earth what happens now is that this water suppose ah so we have this water here now this water will slowly move inside earth, and then it will come out at some point. Similarly, the water that was falling on this tree makes way and then it comes out at some point. So, it is moving inside the earth.

Now, what happens is that water takes time to move from point A to point B. When it was just falling on the surface of the earth and when it was flowing on top of the surface, then it was moving very fast. But once it is inside the ground, then it has to negotiate its way between different soil particles.

So, its speed slows down. So, what happens now is that the water that started here will probably take say 4 months to reach this point. The water that started here will probably take say 3 months. The water that started here will probably take 1 month. And so in the water that started here will probably take a very long period let us say that it takes 7 months.

What is happening through this process is that the water that is falling on the ground, it does not move very rapidly into the streams, and slow in this process the streams are not getting into a flood like situation because this water is now being retained by the canopies, the water has been retained by the soil. And these hills now act as sponges because all of this water is now inside these hills, and so they act as a sponge.

In the case of a sponge, the water is retained inside the sponge, and then it slowly moves out which is what we are observing here. And in this process the floods are avoided because all the water does not reach into the stream at the same point of time. But even more important is that because different waters take different time periods 7 months, 1 month, 2 month and so on.

At all points of time, there is some water that is entering into the rivers which means that even after the rainy season has ended even when we are not having any more rains, we will find that there is certain water that is entering into these speeds through the ground. This is known as ground flow water.

And once that happens, it would ensure that even in the dry seasons the stream will have some amount of water which means that what is now available for the drinking of humans, for drinking by animals, for irrigation purposes, for navigation purposes and so on. Now, these kinds of benefits are known as watershed benefits.

In the case of watershed benefit, we include things like ah the avoidance of flood and also maintaining the streams in a perennial state that is all throughout the year, the streams will be having

water. Now, these kinds of benefits are because we have the forest there and so we need to do habitat conservation.

Now, habitat conservation is being done by the government, it is being done by different societies, and a number of societies do this because of a religious purpose or because of a social purpose. But once we do a cost computation, once we figure out that ok if we did not have these hills, if we did not have these forests, in that case we would have an excess of water that will come in the rainy season.

Now, that excess would have caused floods. And to avoid the floods, you would have to construct a dam. What is the cost of that dam? Similarly, when you have the hills in the forest, the rivers are flowing throughout the year. Now, if we did not have that the dam would have to release the water in a consistent manner.

Now, how many dams would you require so that everybody gets water? What is the cost of that? Once you do these cost computations then these cost computations aid in the conservation policies, they provide support to the conservation policies. This is another importance of doing an economic valuation.

It provides evidence to aid the habitat conservation policies by highlighting the economic value associated with conservation. So, even if we did not have this economic valuation, we would still have been doing the conservation, but with the economic valuation it gets a huge amount of force.

And to evaluate the economic compensation legally required for damage to natural resources through the polluters pay principle, for example an oil spill. Now, if there is an oil spill in an area and the habitat is destroyed, then in the legal process you need to ask the person who spilled this oil the polluter to pay for the damages.

How will you ask this person how much to pay if you yourself do not know the value of your resource. Probably your forest was worth 50 crores of rupees, and the polluter is saying that ok sir I will pay you 5 lakhs of rupees. Now, will you agree or not? How do you figure out what is a good amount of compensation?

The compensation should be such that it should be sufficient to bring your forest back into the original state only then will it be a compensation because a compensation is being done so that the society when it has lost its resource it is able to recuperate the losses, and have the same resource back only then we will call it a compensation.

But if you do not know the value of the resource, how will you ask for compensation? What is the amount of compensation that we need? This is another reason why we do the economic valuation. Now, in economic valuation, the total economic value of a natural resource is given as the sum of its use value and the non-use value. The total economic value is use value plus non-use value.

What is the use value? Use value is a value that arises out of the use of a resource. When you are using the resource, then the value that you are generating because you are using the resource is known as the use value. But then even when you are not using a resource, even then the resource has certain values because we have seen that there are certain resources that are potential resources.

In that case, you are not using the resource currently, they are not actual resources. So, you may use them in the future. And when we talk about those values we say that those are non-use values. Values arising even though the resource is not being used. So, the total economic value is the use value that is arising from the use of resources, and the non-use value which is arising even though the resources are not being used.

And the use value consists of the direct value, the indirect value, and the option value. So, these are the three categories of the use value. Use value is direct value plus indirect value plus option value. What are these three? Direct value comprises consumptive and productive values, and non-consumptive values. What we are saying is that direct value is consumptive value plus non-consumptive value.

Now, this is use value. We saw here that the direct value is a use value. So, these values are arising because we are using the resource. Now, we can use the resource in a consumptive manner or in a non-consumptive manner. When we say consumptive manner, we had seen in an earlier lecture that there are certain resources that are rivals in consumption, and there are certain resources that are not rivals in consumption. Here in the case of consumptive values, we are talking about those values that are rivals in consumption. And when we talk about the non-consumptive values, they are not rivals in consumption.

What are consumptive values? How do you use a forest in a way that you are consuming the forest things like timber or firewood? Now, timber and firewood are consumptive values because if I consume the timber that is I extract the timber out of the forest, then less amount of timber is available for you to extract or for anybody else to extract.

So, the total amount is limited and the more any person takes out, the less is available for everybody else. So, these are consumptive values. People are consuming their influences. Consumptive values are timber, firewood, medicines or medicinal plants. Grazing because even in the case of grazing, the forest has a fixed capacity to accommodate the animals.

So, if I bring in more animals, then for a sustainable use you can bring in less number of animals because if I also bring more animals, you also bring more animals, in that case the resource will be gone. And so when we talk about grazing it is also consumptive use because we are consuming the resources in such a manner that if I use more, then less is available for you to use.

Non-timber forest produce or NTFP, now non-timber forest produce includes things like fuel wood, or fodder, or fiber, or fruits that we are getting out of the forest. So, when we say that we are collecting things such as mango from the forest or we are collecting honey from the forest. So, these things are non-timber forest produced.

So, NTFP is non-timber forest produce. So, this is a forest produce that is not timber. So, everything that is other than timber is a non-timber forest produce. And here we include things such as honey. Now, honey is a forest produce because we normally collect honey from the hives that we find in the forest. So, this is a forest produced, but this is not timber.

Similarly, we have a large number of fibers that we collect from the forest; we have a number of medicinal plants that we collect from the forest. There are a number of aromatic compounds or aromatic oils that we collect from the forest. We also have things like mushrooms that naturally grow in the forest, and we collect them from the forest. So, all of these things are non-timber for-

est produce.

And these are all consumptive values of the forest because if I consume more of the honey, if I extract the honey, then less honey is available for anybody else to extract. Water, water is another consumptive value that we derive from the forest. Non-consumptive values include things like recreation or ecotourism.

Now, in the case of recreation or ecotourism it is a non-rival in consumption which means that if I go to the forest and if I watch a tiger I feel happy about it. Now, here I am using the forest to see a tiger. So, this is a used value. And I am directly using the forest.

So, this is a direct value. But when I see the tiger then it does not reduce the value of the tiger. So, when you see this tiger then the quantity or the quality of the tiger has not gone down because I have seen it before. So, this is a non-conservative use. So, things such as recreational purposes.

If I go to a forest and I find that this forest is very beautiful and I enjoy the surroundings, I enjoy the peace and tranquility in the forest that I am seeing. And when you come to this forest later on then if I have not used the forest in a way that if I have not littered into the forest.

If I have not spread waste into the forest then there is no change in the value; and when you go to the forest later on, you will also enjoy the forest. So, things like ecotourism or recreation are non-consumptive values. Similarly, we have education and research. So, if I go to the forest, and if I do a research project about how tigers regulate the population of deer. I do this research. Now, when I do this research, I am just going into the forest and counting how many tigers are there, how many deer are there, when they hunt, how they hunt and so on. Now, in this process I am neither reducing the quantity of tiger or deer nor am I reducing the quantity of tiger or deer.

Now, later on suppose you come up with another research proposal that how does tiger regulate the growth of say some birds in the forest. So, while I have used the forest to do my research work, it has not reduced the quality or quantity of the forest for you to use it as a research area. So, this is again a non-consumptive use of the forest.

Similarly, human and wildlife habitat. If I am using the forest as a wildlife habitat or if I am using the forest as a human habitat, so if there is say ah a rest house in the forest I go into the forest and I use that rest house because it has a very beautiful surroundings.

Later on if you go into the forest, you stay in the rest house then it does not matter whether I have stayed before or not as long as I am using it sustainably and I am not destroying it. So, these things are known as the non-consumptive values that we derive from the forest.

And direct value is the sum of consumptive values and the non-consumptive values, because in both of these whether we are talking about consumptive usage or non-consumptive usage we are using the forest directly. There are also indirect values that we derive from the forest. Indirect value means that we are still using the forest, but the values that we are deriving out of it are indirectly.

We are not directly deriving these values. So, this includes things like watershed benefits including agricultural productivity, soil conservation, groundwater recharge, regulation of stream flows. We have seen before that the watershed benefits that the forest provides lead to protection of soil, they lead to availability of water throughout the year.

But when somebody gets an enhanced income because of the presence of soil and because of the presence of water throughout the year, this person will not say that I am getting this value or this amount of money because of these forests because they are not directly using it. It does not come to their mind that they are directly getting these values, but they are still getting these values indirectly.

It includes things like ecosystem services: nitrogen fixation, waste assimilation, carbon sequestration and storage, microclimatic function, now all of these things are also indirect values that people are deriving because of the presence of forest the climate is kept much more moderate.

The global climate or global warming is kept under check. Now, the benefits of these things will be derived by everybody, but they will not say that oh ah this year I am I did not get a drought situation because of this forest. It just does not come to mind, but it is still a value that people are deriving indirectly.

Or things like evolutionary processes such as global life support and biodiversity. Now, when we talk about the organisms that we have on earth and we are deriving values from different organisms, these organisms also require a place to live. When we talk about polar bears.

When we talk about tigers, when we talk about leopards, leopards require a place to live. Now, we derive a benefit out of seeing a tiger, but then the forests are the areas that provide it with the habitat the forest are the areas which ah which provided an opportunity for a tiger to evolve into what it is today. So, these are also benefits that people derive indirectly.

So, these are the indirect values. And we also have the option value. It is an option for the future direct and indirect use of biodiversity. Now, what is an option? Suppose, there is a forest and we have got two options. One is that we can go into the forest. We can cut all the trees and extract the timber out. Now that is one way of using this forest.

But you may also say that no this forest has certain biodiversity and I might use it in the future. So, I am not currently using it, but I might use it in the future. So, let us keep it as a forest. Now, this value that you derive for a future use is an option value. You can make a correlation by saying that suppose there is a house.

And you want to purchase this house. Now, you can buy this house for, say rupees 60 lakhs, but there is also another house that you think that ok this is also a good house I might purchase this house again. So, we are not sure whether you will buy this house and suppose this house is worth 65 lakhs, and this house is 60 lakhs.

Now, you are not certain which house to buy, probably you will ask a few of your friends, you will ask a few of your family members, you will do a bit more research, you will do a bit more feel with it, to make up your mind which house to buy.

But then when you are in this process the seller of the house might say that ok sir you are taking so much time, so let me sell this house to somebody else because there are so many people who want to buy this house. Now, the thing is you have not decided which house to buy, but you are sure that you are going to buy a house.

What you can do is you can tell these sellers that ok I want you to keep this house for me for say the next two months. By the end of these two months, I will make up my mind. Can you please keep this house and not sell it to anybody. The seller would say sir why should I do that because

as soon as I get a buyer, I will sell this house.

So, you tell these sellers that ok, I am going to pay you 20000 rupees. And I am paying you to these 20000 rupees so that you do not sell these houses in the next 2 months that is what you are doing is that you are paying rupees 20000 for this house, and you are paying a rupees 20000 for this house just to keep it like that for the next 2 months till you are able to make up your mind.

Now, this amount that you have paid 20000 here and 20000 there is an amount so that you retain your option. You are paying this amount, so that these houses are not sold before you make up your mind, and you retain an option on both the houses. This is an option value.

Similarly, when we say that there is a forest and we are not extracting this forest, we are not taking out all the resources because we might use it in the future. Now, we do not know when we are going to use it or whether we are going to use it, but we still want to maintain an option in the forest.

Then later on should we decide that we are going to use this forest for say um getting a particular drug then this forest should remain. Now, this is a value that we derived from the forest just by keeping it as such. So, this kind of a value that you derive is an option value, an option for the future direct and indirect use of biodiversity.

So, these are the three different use values: direct values, indirect values, and option values. Similarly, we have the non-use values: value that is arising even though the resource is not being used. And here we have existence value, altruistic value and bequest value. So, these are three non-use values. What are these?

The first is existence value: this is the value deriving from the knowledge that the resources continue to exist. What we are saying here is that we know that there are polar bears, and a lot of us would have probably seen polar bears on the television. Now, suppose one day you get to know that all the polar bears have become extinct, how will you feel about that? Probably a lot of us will feel very bad that polar bears are now extinct.

But now if you think about it, you are not using a polar bear, you are not using a thing like the pandas, you are not using the whales that are there in the ocean, but even then if these animals become extinct you will feel bad that you now no longer have these animals on the planet. Now, you have lost the chance to ever watch these animals, or your children and your grandchildren have lost the chance to ever see these animals.

When we say that we feel bad, the other thing is that when the resources continue to exist we do not feel that bad or we feel good. We feel good that yes on this planet we still have polar bears.

Even though we are not going to the arctic regions and watching the polar bears, still we feel good that yes we have the animals. Probably someday we might go and watch these polar bears, probably we will never go and watch these polar bears, but still we feel good that yes the polar bears continue to exist.

Now, when we talk about these values these are the existence values. This is a value that we derive from the knowledge that the resources continue to exist. So, if there is a forest and you get to know that the forest is burnt that is ah every year we get to know that there are huge forest fires and so many millions of ah acres of forest are getting burnt.

Whenever we see such a news, we feel bad; or the other way around this if this forest had contin-

ued to remain as it is they would have been good. So, the value that we derived just because the forest continues to exist is the existence value. So, this is a non-use value because we are not using this resource.

Another is altruistic value, the value derived from the knowledge of use of resources by others in the current generation. So, when we find that there are rhinoceros in the Kaziranga National Park and because there are rhinoceros in the Kaziranga National Park so many tourists visit Kaziranga National Park.

And because they visit, people in the surroundings get employment. Now, who are these people? These are our own country people, they are our own brothers and sisters, they are the citizens of the same country. Now, these people are there in the same generation as we are.

And we feel good that ok because of the rhinoceros there are certain people in our country who are getting employment. So, we feel good that yes even though I am not getting a value out of these rhinoceros directly because the tourist is not paying me, but at least there is somebody in my country who is getting employment because of the rhinoceros.

Now, this value that we'll derive because we are getting the knowledge of the use of resources by others in the current generation. Now, in this case we are not talking about our children, we are not talking about our grandchildren, we are seeing that yes today there is somebody in our country who is getting employment because of rhinoceros.

Now this kind of value that we derive because we are feeling good that there is somebody who is getting employment - this is known as an altruistic value. Now, this is a non-use value because we are not using those rhinoceros, but we still feel good that yes there are certain people in our country who are getting employment for using these resources. So, this is an altruistic value.

And when we leave these values for our offsprings or future generations then we will say that we are having a bequest value. So, the bequest value is when you ask the question, ``Ok, today if I am generating a waste, today if I am polluting the environment, what am I giving for my children and for my grandchildren?''

Everybody wants to leave the world in a better place for their children and their grandchildren than they are currently living in. And when we have this kind of a thought when we say that ok we are leaving these forests for our children and our grandchildren.

We are ensuring that we still have tigers so that our children and our grandchildren can watch tigers. When we have such kinds of thoughts then the value that we derive because we have tigers for our children and our grandchildren is known as a bequest value. So, this is another non-use value.

Now given that we have so many values we can now talk about the methods of valuation. How do we put a rupee value or a dollar value to all of these different values? There are three accepted approaches for valuation of the natural resources. The first one is known as market prices or the revealed willingness to pay.

In the case of market prices, we have three main methods. One is the market price method, the hedonic pricing method, and the travel cost method. The market price method asks the question that ok if we use these different values what is the market price for each of these? That is when we talk about the market price method for a forest we will say that this forest has timber.

Now, if we extract all of this timber, what is the amount of money that we will get by selling this timber? So, let us say that the amount that we will get is 30 crores of rupees. This forest also has water. Now, if we extract all of this water and we try to sell it off, what is the amount that we will get?

Suppose, we will get 10 crores of rupees. In this forest we have a number of animals such as fishes. Now, if we extract all the fishes what is the total value that we will get when we sell it in the market? Suppose, we can sell it off for 25 crores. And similarly we can make a list of all the other birds that we are getting from the forest.

And what we are asking is if we extracted all of these out and if you sold it in the market what is the price that we will get. Suppose everything else is going to give you 15 crores. Then the market price method would say that the total value of the forest in crores is 25 plus 15 is 40, 50, 60, 70, 80.

So, this forest is worth 80 crores of rupees. This is the market price method. You make a list of water and things that are there in the forest, find out their current market prices, add them together, so that is the market price method. Another is hedonic pricing method, hedonism is the value of feeling good and the feel good factor.

Now, the thing is, suppose there is a tower. And this tower has different flats. And on one side of the tower, you have a forest; on another side of the tower, you have a road. So, here you have a road. And on this road, there are vehicles that are flying, and there is a huge amount of noise that we get and it does not look good.

But if you look at the forest, it looks good, it is a beautiful forest. Now, when that happens and when the flats are put up for sale, suppose we have these two flats A and B. Now, the person who gets flat A will get to see the road, and the person who buys flat B will get to see a forest.

And typically what we observe is that the flat BB is sold at a premium because it gives a very good view. So, it is very similar to having a sea facing view. So, sea facing plots or flats cost much more than a non-sea facing flat. And similarly here a forest-facing flat will cost much more than a non-forest facing flat.

Now, the hedonic pricing method asks this question that people are paying this premium because they are deriving a benefit in the form of happiness in seeing this beautiful forest. And so if we did a computation of the prices of all of these and the prices of all of these, the difference is because these portions are towards the forest.

The difference in prices between both of these will give us a certain amount of value that is coming from these forests. So, that is the hedonic pricing method. Another is the travel cost method. Now, the travel cost method is based on the idea that people put a value on things. And if the price is less than the value that they are putting only then will people be purchasing that particular item.

That is if I put a value to this pen of 50 rupees, and if I am getting it for 30 rupees, I will buy this pen. But if I am getting this pen for 100 rupees, I will probably not buy this pen. So, the amount that I am paying can give a very good idea about the minimum value that I am putting to this thing. That is if I am paying 30 rupees for this pen, then that would mean that the value is greater than or equal to 30 rupees only then I am paying for it.

So, when we talk about the travel cost method, it asks the question that if there is a forest let us say there is the Kanha tiger reserve. And people are coming to Kanha tiger reserve from different areas. So, let us say that there is a person who is coming from Delhi, there is a person who is coming from Mumbai.

Now, the person who is coming to this forest is spending money on transportation, this person is spending money for entry fees, this person is spending money for ah paying for the accommodation and food at higher prices than what he would he or she would have paid at home. Now, if a person from Delhi is spending say 30000 rupees to come to this forest; a person from Mumbai is spending say 40000 rupees to come to this forest.

So, the person from Delhi is putting the value of at least 30000 rupees because of which he is spending this amount the person from Mumbai is spending is putting a value of at least 40000 rupees. And so in the case of the travel cost method, we make a list of the people who are coming to the forest, and we make a computation of how much they have spent.

When we add them up together, then it gives us an idea of the value that these people have come to the forest, so that is the travel cost method. Another approach is the circumstantial evidence or the imputed willingness to pay such as a replacement or substitute cost or damage cost avoided. Now, in this case what we are asking is suppose there is a sea and we have a mangrove forest near the shore.

Now, if there is a tsunami, then all these areas will get inundated with water. And there will be a loss of life, there will be a loss of property. Now, when we talk about the damage avoided. We are asking the question that if our ah mangrove forest were not here, because mangrove forests protect against the impacts of the tsunami they act as barriers to the water that is coming in.

Now, if we have the mangrove forest, then they are protecting the inland areas. If it did not have these forests, then there would be damage that would be caused to the inland areas. What is that damage? And when we do a computation of what would be the damage caused if we did not have this natural resource.

And we put that value to this that this forest is giving us a protection that is worth 1000 crores of rupees then that is a damage cost avoided method of valuation. On the other hand, we could ask another question: if in place of having this forest we removed all the trees and if we constructed a wall along the shore.

Now, this wall would also protect us against the tsunami. But the construction of this wall will cost us money. So, what is the cost of construction? What is the cost of maintenance? So, that is the cost that we would have to spend to have the same level of protection if the mangrove forest was not there.

When we ask that question we are asking about the replacement or the substitute cost, how much does it cost for the replacement of the natural product or the natural resource? If we did not have the forest, we would have to construct structures to prevent soil erosion, how much would those structures cost?

If we did not have the forest, we would not have clean water. And we would have to start a plant to clean the water. What would be the cost of constructing and running that plant, so that is the cost of the replacement. So, this is also a method of valuation of the natural resource. And a third

method of valuation is surveys or expressed willingness to pay such as the contingent valuation method.

In this case you ask people the question that ok, there is this forest and you give them a hypothetical situation that the government has decided that this forest should be cut down. But if we pay to the government in the form of a tax, then probably the government will not cut down this forest. What is the maximum amount that you are willing to pay?

Now, the people who are deriving value from the forest will put up a certain amount ok, I am ready to pay 20 rupees or I am ready to pay 1000 rupees, or I am ready to pay 10,000 rupees. So, depending on the amount of value that they are putting to the forest, they will come up with a certain figure.

Now, this is a completely hypothetical situation, but we are getting an indication of the amount of value that people are putting into the forest by the amount of money that they are expressing that they will be willing to pay for the continued existence of the forest. So, that is known as a contingent valuation method through service or express willingness to pay.

Now, different methods of valuation are used for different areas. And we can choose between these different methods depending on the situation that they are addressing. So, in this lecture, we had a look at the total economic value. Total economic value is use value plus non-use value. Use value is direct value plus indirect value plus option value; non-use value is existence plus altruistic plus bequest value.

These are all different values that we derive from the forest. And we can make a computation of their rupee values or their dollar values by using different methods of valuation. And this is used so that we get an idea of the resource that we are protecting.

We get an idea of how much it will cost somebody if this resource is to be diverted, we get an idea of computing the damages, and it also helps us in reinforcing our policies for conservation. So, in this case, economics is a very good tool to aid conservation because it helps us make choices in a rational manner.

That is all for today. Thank you for your attention. Jai Hind!

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Module 12
Case studies
Lecture 1
Economics of Protected Areas

Namaste! Today, we begin with the 12th module which is case studies. This module will have 3 lectures Economics of Protected Areas, economics of environmental disasters part I and part II. Let us begin with the economics of protected areas.

Protected areas are defined under section 24 A of the wildlife protection act 1972. Protected areas means, a national park, a sanctuary, a conservation reserve or a community reserve notified under sections 18, 35, 36A and 36C of the Act. So, the protected area is a national park, a sanctuary, a conservation reserve or a community reserve.

And we have a number of wildlife that are found in the protected areas. What is wildlife? Wildlife is defined in the Wildlife Protection Act 1972 as: wildlife includes any animal, aquatic or land vegetation which forms part of any habitat. What we are saying here, is that if you have any animal or any plant that forms part of any habitat then we will say that it's a wildlife.

And the dictionary definition of wildlife is: wild animals collectively or the native fauna and sometimes flora of a region, which means that it is saying that the native fauna which is the native animals and the native flora which is the native plants. So, those animals and those plants that are found natively or which are indigenous to an area, if we look at a collection of those we will call it wildlife.

Wildlife are divided into these nine threat categories by the international union for the conservation of nature and natural resources. So, we have a red list of different organisms which tells us what the level of threat is. For certain organisms whether plants or animals the level of threat is so large that if we do not protect those animals and plants, then in a short while it is very likely that these plants and animals will become extinct.

On the other hand there are certain plants and animals that are not that threatening so, in that case we may not protect them to such a high extent. Or let us say that it is not an urgency to protect them right away. So, these threat categories are extinct. If an organism is extinct it means that there is nothing much that you can do about it. This organism just does not exist anymore.

Things such as the dinosaurs or the dodo bird are currently extinct, they are no longer found in this world. Certain other organisms are extinct in the wild, which means that we may have a few specimens of these organisms in a zoo, but if you look out in the wild conditions, we do not have any of these organisms left. Then we have critically endangered organisms, endangered vulnera-

ble, near threatened and least concerned.

An organism that is in the least concern such as the common dog or the cow, we do not need to provide them with the level of protection that is urgently required for say a critically endangered species such as the tiger. Then for a number of organisms we do not have the data.

We categorize them as data deficient. And, then we also have certain organisms that have not yet been evaluated and we call them not evaluated. So, there are several species that are in need of conservation, and the higher a species is on this list the more is the amount of conservation that it urgently needs.

This list gives us an idea of how we prioritize things. You will remember it is a principle of economics that there are tradeoffs involved in a number of things, well we would ideally want to conserve each and every of these organisms, but then our time is limited and our resources are limited. If we have to spend our time and resources, we should prioritize those species that require a greater amount of conservation and those species for which we can actually do something.

A scientific way of looking at which species to conserve looks at whether or not they are keystone species. Now, keystone species play critical ecological roles which means that they have an importance that is much greater than their numerical abundance in an ecosystem. So, things such as off season fruit bearing trees are keystone species.

What we mean by a keystone species is that the impact that these organisms have on an ecosystem is much greater than their numerical abundance, so, if there is a forest that is completely dry, and this forest is having a scarcity of food. But, then if you have a tree that can provide food to different animals and birds, then this tree would act as a keystone species.

Because, even though you have a single tree that is providing the food, it is able to support a large variety of plants and animals and keystone species include species such as the ficus trees, banyan trees, peepal trees. So, these are those trees that provide food in the off season, and also their leaves and their branches are all edible and they are large in size. So, if you have a look at a banyan tree; a banyan tree would be supporting say hundreds of organisms from small insects to reptiles to birds.

These sorts of species are known as keystone species; another keystone species is the tiger. Because, if you have a tiger in an area then the tiger regulates the number of herbivores that are there so, the herbivore population is not able to cross a threshold. Because, if there are too many herbivores then it is possible that they will eat up all the vegetation in the area, and the whole ecosystem would collapse. Species that are keystone species need to be given a greater priority when we talk about conservation.

Other species are known as umbrella species; these are species with large home ranges. So, what happens in the case of these species is that they have such large home range requirements, that if you make it a point to conserve these species or the other species in the large home range will automatically get conserved. So, here we have species such as the elephant or again the tiger.

An Amur tiger has a home range of around 800 square kilometers, in India we have tigers that have home ranges of roughly 80 square kilometers. So, if you are conserving the tigers, for each tiger roughly 80 square kilometers of area automatically gets conserved, all the different organ-

isms that live in that 80 square kilometers are automatically afforded protection, because we are conserving the tigers or species such as the elephants.

They also have large ranges. So, the species that have very large home ranges act like an umbrella to provide protection to a large number of species, just because these umbrella species get protected. So, again they should get priority when we are talking about conservation.

And the third is flagship species. Flagship species are well known charismatic species that have captured the public's heart and won their support and funds for conservation. Examples include the giant panda, the humpback whale, and the gorilla.

When we talk about flagship species these are those species that attract people. It is possible that a few of these species are beautiful species such as the peacock. So, peacocks are a flagship species because they are beautiful. People want to see peacocks or you could have species that are very majestic such as the tiger. So, a tiger becomes a flagship species because people are in awe of seeing a tiger. Or you could have species that have religious significance such as the elephants.

Now, these species that are the flagship species, they occupy a space in the hearts of people. And so, when you want to conserve these species it is easy to get funds and it is easy to get public support. So, those species that the public likes should also be given a higher priority in conservation. So, these are the flagship species.

Now, when we do conservation we try to look for those species that make all these three definitions. So, if there is a species that is a keystone species which means that it has a very large role in the ecosystem. It is an umbrella species which means that it requires a large home range, which would automatically give protection to a large number of other species. And, if it is also a flagship species which means that people want to conserve this species, they are and it is easy to get funds and public support, nothing like it.

We always look for those species that are at the conference of all three of these. A good example is the tiger. Because a tiger is a keystone species it's a flagship species and it is also an umbrella species. So, by protecting tigers or by allocating funds for the conservation of tigers, we are able to achieve a lot of our goals of conservation.

Now, in this context it is prudent to memorize. Why are these species threatened, why are we doing this conservation at all, why are we setting up these protected areas? So, we had seen earlier that there are a number of factors that lead a species to extinction.

So, there are factors that act at large population sizes and there are factors that act at smaller population sizes. And, we can summarize these factors with the acronym HIPPO: habitat loss, invasive species, pollution, human overpopulation and over harvesting are the factors that have been driving species towards extinction. And, when we are talking about protected areas, they protect the animals and plants that are inside from these five things.

When we want to protect species against these factors of extinction there are two modes that are there with us. We can either take the species out from the natural environment, and give them a very high level of protection, say in a zoo.

What happens in a zoo is that you bring the animals from the natural environment, you keep them in controlled conditions, where they get sufficient amounts of food, sufficient amounts of

water and a very good veterinary care. That is one way. The other way is that you can protect these species when they are out there in their natural environment.

That brings us to two modes of conserving wildlife, we can go for an ex situ conservation, which is conservation which is off the site that is conservation outside the natural habitat. Such as in the case of zoos or aquariums, or we can have in situ conservation which is conservation on the site which means that conservation done that is within the natural habitat such as a national park.

How do these work? In the case of ex situ conservation, it is required for critically endangered species, because it provides urgent intervention so, in the case of critically endangered species. Because the numbers are so low, we need to give them a very high level of intervention and very intensive management which may not be possible in the wild conditions.

So, ex situ conservation is probably the only way out, to conserve those species that are critically endangered. So, in the case of ex situ conservation we designate areas with suitable conditions and we create facilities. So, in the case of ex situ conservation an area will be selected to make a zoo.

And, then we will create the facilities for a zoo. That is we will surround this area with say a wall, we will provide means of bringing in water means of bringing in food. We will create facilities such as a veterinarians office, say an operation theater and things like that, and once these are done the species are moved into these designated areas for their survival and breeding. And, in a number of cases we also do ex situ breeding of these animals, the captive breeding of animals.

So, what will be done is that these animals that are critically endangered, they are brought into these zoos and they are allowed to breed and when the population goes up. Then, it is also possible that we can later release them into their natural habitats. So, that is ex situ conservation.

It has a number of advantages, it allows better control of variables such as climate, diseases, diet and so on. Because it is a small area the intervention is much more intensive and so, it is much easier to provide them with standardized conditions. It provides opportunity for close observation to better understand the species and the proximate causes of its extinction. So, it provides us with an opportunity to understand the behavior of animals.

Suppose in a zoo environment you get to know that this animal avoids breeding, if it is exposed to too much sunlight. Then, probably when we release these animals back into the natural environment, we will make sure that we release them into an area that has a very good canopy cover. Such kinds of observations are extremely indispensable, when we want to conserve the organisms. And, then they also permit intensive interventions such as in vitro fertilization, embryo transfer and so on. So, we can provide all sorts of modern scientific advancements and medicines to these organisms.

However, it also has certain disadvantages, because we are taking the animal out of its natural habitat and we are conserving those few animals, but in this process we are not conserving the habitat. It is possible that you remove all of the critically endangered species individuals from the natural environment, bring them to a zoo, do a captive breeding, but in the meantime their natural habitat gets destroyed completely.

That would defeat the purpose. So, this is one disadvantage. It can be planned for only a few

species at a time because it is very expensive. We are doing an intensive intervention. So, the costs go up and when the costs go up, then it is difficult to do it for a very large number of species or a very large number of individuals.

Some wild behaviours may get lost because we are not keeping the organisms in a wild setting and so, it is possible that while a few of these organisms are able to survive and breed. But, they will lose out on their natural behaviours like, where to look for food or how to hunt. So, this is another disadvantage: captive bred and raised individuals may then find it difficult when they are reintroduced.

Because they are now completely dependent on human intervention, they do not know how to hunt for food. In that case once you try to release them back into the environment it is possible that they will just not be able to cope with the conditions. Then, it may increase the chances of inbreeding if it is not planned properly, if the spread books are not maintained properly, it is possible that brothers and sisters or parents and offspring might breed with one another.

In that case the number of recessive disorders will go up and then finally, it is also costly. Now, throughout this course we have observed that price or cost act as very good indicators about different activities. So, if it is costly and money is one input that you are able to provide, then you will have to also look at the trade off. Can this money be better spent in protecting the habitat than in setting up a zoo.

So, these kinds of questions need to be answered. Examples of ex situ conservation include zoos, aquaria, captive breeding facilities, botanical gardens, bambuseta, arboreta, seed banks cryopreservation facilities, such as tissue culture sperm bank ova banks and so on.

In all of these what we are doing is that we are taking the organism, or its body parts away from the natural setting. And keeping them in a very scientifically managed facility provides a very intensive intervention, with the hope that probably some day in the future, we will be able to release them back into the environment once the numbers have gone.

So, this is ex situ conservation the other mode of conservation is in situ conservation which is conservation on the site. In this, areas in the natural habitat are designated as reserves, national parks or protected areas. And, in these ecological monitoring and interventions, such as active management are done and legislations are required to maintain these areas after test protected areas.

What we do in the case of in situ conservation is that first of all, we designate a place as an in situ conservation facility, such as a national park or a wildlife sanctuary or any other modes of protected areas. Now, different countries may be using different terms, but you get the idea. So, the first step is to use legislation to designate an area as a protected area, or as an in situ conservation area.

Once we have done this designation, then laws will be used to ensure that people do not enter into this area or to regulate the movement of people into this area. And, also we do active interventions: that is active management such as control of forest fires or control of invasive species or provisioning of water. So, all different kinds of active management are also done in these areas.

It provides several distinctive advantages the species continue to live, in their natural environ-

ment which means that the natural behaviours are maintained in these areas. Then, this is less disruptive and more importantly it is less costly, because the only cost that is involved is doing a legislation, to designate these areas as protected areas.

And probably do a bit of protection, a bit of habitat planning, we do not have to set up facilities such as veterinarians office or an ot or cages for individual organisms, you do not have to bring in food from outside to feed these organisms and so on. So, it is much less costly as compared to an ex situ conservation facility.

Then, protection of the natural habitat provides protection to other species as well. So, if you are trying to conserve tigers by creating a tiger reserve, then not only is the tiger protected. But, the other species that live in the forest also get protection automatically. Whereas, if you are trying to conserve tigers using ex situ conservation facilities, you would have brought the tiger outside, you would have conserved the tiger, but when its habitat gets destroyed then the other species will also be in peril.

And so, a distinctive advantage of in situ conservation is that it provides protection to other species as well. Then, even in the case of ex situ conservation the animal will need to be released somewhere in some point of time. Once you have done the captive breeding in the case of ex situ conservation you have now a large number of animals. So, they will have to be released back into the environment.

If you only did ex situ conservation you only maintained these individuals in the zoos, and their natural habitats got destroyed in that case where would you release these organisms. So, in situ conservation is also important together with ex situ conservation, because it keeps certain portions of the habitats of these organisms intact so that you can release them there later on. These provide suitable areas for such releases and they also double as places for scientific studies and public awareness and things such as tourism.

The disadvantages include requirement of very large areas, because in the case of in situ conservation, what we are doing is that we are designating very large areas as protracted areas. So, the area requirement or the land size requirement is much greater. In the case of ex situ conservation such as a zoo, you can keep animals at a much greater density.

But, in the case of in situ conservation such as a tiger reserve or say a national park you will have to keep these animals, in the natural settings in which case it will require a much greater area. There is less intensive protection and management, because the areas may be encroached upon or the animals needed poached. Why? Because these areas are so large that it is not possible for you to man all of this area at all times. So, it is possible that a poacher might get into a national park and kill a few of your animals.

Which is very difficult in the case of an ex situ conservation facility, because we have erected huge walls. And, also because in the case of an intensive intervention, it is very easy to keep an eye on each and every animal, probably you could even make use of CCTV cameras. But, in the case of in situ conservation this becomes difficult because the area is so huge. Then, there are always the threats of diseases and disasters, because it is a large area you are not able to manage everything at all points of time.

And, a large establishment is required in each case; establishment in terms of people who are go-

ing to man the area establishment in terms of vehicles, because these are large areas. So, you have to go to two different areas to observe these animals to protect these animals. In that case you might even require say forest rest houses in certain locations. A large amount of establishment may also be required in the case of in situ conservation.

Now, when we say that we are going to do an in situ conservation, there are certain traditional ways of creating the protected areas. How did the kings of the bygone eras used to make a protected area? One option was to look for beautiful areas. So, if an area is a beautiful area the king would say ok, these are such beautiful areas let us make them into a national park. Lush green mountains, lakes, beaches - they used to be converted into protected areas for the enjoyment of the king.

In certain cases certain high species diversity areas used to be converted into protected areas, such as the silent valley national park in Kerala or in certain cases those areas that harbor unique animals endemic organisms that are found nowhere else would be converted into protected areas. Such as the Gir National Park in Gujarat that is the only home of Asiatic lions in India. But, in a number of cases these become a bit too haphazard and based on the whims and fancies of the reserve creator.

So, with time we have shifted from these traditional ways of creating protected areas, to the scientific ways of creating predicted areas. In the scientific way we look for those areas that are high in species richness, species endemism and that have a moderate level of threat to the species.

What is species richness? Species richness refers to those areas where you have more number of species per unit area. So, if we look at say things like global mammalian richness. There are certain areas that have a large number of species per unit area and there are certain areas that have a smaller number of species per unit area.

So, we can look at global mammalian richness, or we can look at amphibian richness, then we can also look at the number of species that are under threat. So, there are certain areas such as in Southeast Asia that have a much greater level of threat than say an area in North America. Then, we can also have a look at different categories of species such as the number of amphibian species in death threat.

What we do is that we look for those areas that have high species richness, which means these areas have a large number of organisms. And, if you create a protected area in one of these locations, then we will be able to afford protection to a very large number of species. Because these are the areas with high species richness, we look for those areas that have a high degree of endemism. So, if an organism is only found in one area, you will have to provide protection in that area.

Because, if you do not do that, that species will become extinct very soon and we look at those areas that have a high degree of threat, or at least a moderate degree of threat. Because, if we have an area that does not have any threat, say an island that nobody ever goes to. So, in that case, because our time, money and resources are limited, then it is much more prudent to make a protected area probably in a threatened region than this Island.

Because, even if you did not convert this Island into a protected area, the species would have re-

mained fine there would not have been any difference or there is no impact of making a protected area in such a location. So, we look for these three criteria and those areas, which have all these three high degrees of richness, endemism and threat we call them as biodiversity hotspots. These are the biodiversity hotspots in the world and in our country areas such as the Western Ghats are a biodiversity hotspot. Because we have a very large number of species that live in these areas, there is a very good amount of species richness. We have a number of species that are only found in the Western Ghats such as a number of the amphibian species. So, there is a very great amount of species endemism.

And the Western Ghats are also threatened because people want to cut these forests and convert them into certain other uses. In that case these areas also have a high degree of threat. So, these areas that are the biodiversity hotspots, they need to be afforded greater amounts of protection.

And, in this case we should also have a look at the threat triage that we have. So, if there is an area that has a very high degree of threat, then probably it is already a lost cause. Because by that time you would be able to convert this area into a protected area, maybe set up mechanisms for the protection of this area, set up mechanisms to do habitat management, by that time, because of the high level of threat probably, it would already been taken over on the other hand if you have a location that has a very low degree of threat. There too it does not make any difference whether you make a protected area or not. Because, the animals or the organisms in this area would remain fine, whether you make a protected area or not there is absolutely no threat in those areas.

So, the areas which have a very high degree of threat or the areas which have a very low degree of threat, they are not that preferred. But, those areas that have a medium degree of threat are more preferred because, in those cases we will be able to put in a much greater impact by converting those areas into protected areas.

So, we need to keep in mind that threat triage is built and we should also keep in mind the gap analysis. The gap analysis approach tries to identify holes in the existing network of protected areas, that are primarily in locations that are or were historically uninhabitable for humans due to their heights, prevalence of diseases, or other reasons.

And creating some protected areas in human dominated areas may fill the gap allowing a different set of species to thrive. Now, what we are saying here is that in the case of the existing network of protected areas, people normally went for those areas traditionally that were not of much use.

So, you would hardly find a protected area in or near a town or a city, you would only find protected areas in those mountains that were very difficult to reach or those areas that were infested with mosquitoes and malaria, because of which people did not want to go to those areas. So, the rulers used to convert those areas into protected areas.

Now, because we have inherited such protected areas. So, a number of protected areas today are in those locations that are not built within reach. Whereas, those areas which were which could be dominated by humans, such as the plane areas. They were completely converted into agricultural lands. Now, gap analysis says that because we created our earlier protected areas in the mountains, we are able to protect the mountainous species, but we did not create any protected areas in the plane areas. So, if we have a chance let us at least create a few protected areas in the

planes or those locations that are human dominated. Because, once we do that we will also be able to provide protection to the species that live in plane areas or those areas that have become human dominated.

So, that is gap analysis. You take a map, mark out all the protected areas and look for the gaps, and those gaps are the areas where you should be making them protected areas, that is the gap analysis and whenever we are making a protected area. Whenever we have the chance to make a protected area, there are certain principles of reserve design that should be kept in mind. Whenever, we are making a protected area go for a larger size. So, big is better than small.

Why because a bigger size means more number of habitats, which means a higher species diversity that you will be able to afford protection too. If you make a very small protected area, then you will be able to provide protection to less number of species and less number of habitats. But, if you are able to construct a large size reserve, then you will be able to provide protection to a large number of species that live in the diverse habitats that you have converted into the protected area.

Second thing is that they are more secure and easier to manage per unit area. Why are they more secure? Because, in larger areas we have larger populations, if you have larger populations then they are less susceptible to extinction. Because, you will only have those factors of extinction working there that work at the larger population sizes, but the factors of extinction that work at smaller scales the stochastic factors will not work in these larger areas.

So, the populations are inherently more secure from extinction, then in the protected areas you need to protect the perimeter. Because, the perimeter is where people can get into whereas, the species get protected in the area. Now, as you increase the size of a protected area the ratio of perimeter to the area of of this reserve, it reduces which means that it becomes much more cost effective to provide protection to this reserve.

So, the larger the size of the reserve it has the smaller perimeter per unit area, which makes protection more cost effective. Then, these are also less vulnerable to catastrophes, because smaller catastrophes will not impact the whole area.

Another principle is that one big is better than several small of the same total area, which means that if you have an option of making one big reserve, or four smaller reserves, or five smaller reserves, and the total area is the same in both the cases you should probably go for the largest sized one not a number of smaller ones. Why?

Because, these smaller ones will not be able to support those species with large home ranges. So, they will be only able to support those species that have smaller home ranges. Whereas, this large area will be able to support those species that have smaller home ranges, but also those species that have larger home ranges. So, one big is better than several small of the same total area.

But, then if you cannot make one big one if you only have the option of smaller ones, then go for those smaller reserves that are close together. Because they minimize the isolation, what happens is if you have these reserves that are close by the animals may go from one area to the next area. And in that case it may be able to support at least some of those species that have higher home ranges. So, closer species minimize isolation. So, they should be preferred; those reserves that

are very far from each other should be less preferred.

Then, you should go for a cluster approach, if the species are together in the form of a cluster it is more preferred than a linear arrangement. Because, in the case of a clustered approach the species from this reserve can go to this reserve, and it can also go to this reserve, the species in this reserve can go to this reserve, but also to this reserve.

So, the amount of movements increases whereas, if you have the results that are lined up in a linear fashion, then the organism says this reserve can only go to this reserve. So, the movements are more restrictive in a linear fashion. And, if possible go for a circular looking reserve, because circular reserves have less biotic pressure which means that the influence of humans that are there in the periphery say if it reaches to this distance. So, at least this area in the center will be protected. So, the core area of the reserve will be protected.

Whereas, if you have a reserve that is linear in structure, in that case the influence of the humans in this place will probably go to more than half the area of this reserve. And, in that case everywhere you will find an influence of humans and so, the level of protection in a linear reserve will be much lesser.

But, then we also have a number of linear reserves and we have already observed that in the case of the Mudumalai Tiger Reserve, if you make a 10 kilometer buffer from the habitations, you will find that the whole of the reserve is completely covered with these buffer areas. So, the circular reserves need to be promoted more than linear reserves such as these.

And if nothing else happens at least maintain the connections, because through these connections we can ensure that the organisms have free movement. And, in that case some species that have larger home range requirements, they will still get some level of protection.

But, if we have these reserves in the form of Islands what will happen is that in the absence of movement, we will find a large amount of inbreeding in each of these different reserves. And once that happens the level of protection goes down.

Now, we routinely make use of these approaches whenever we are making new protected areas. So, for instance in the state of Madhya Pradesh when we were looking for new sanctuaries we looked at biodiversity intactness. Now, the biodiversity intactness index tells us the level of biodiversity that remains in different areas.

So, if you look at this map, these sections that are darker in color have more biodiversity, these areas that have a lighter color have actually lost their biodiversity over several years. Whenever we are making a protected area we should ensure that there is a high level of species richness or biodiversity. So, these areas which are dark in color need to be selected.

Then, through a gap analysis we can look at those areas where you already have the reserves. And make results in those areas that are away from these and when we try to maintain the connections what we do is that suppose you consider this reserve and this reserve. So, here you have the Madhav National Park and here you have the Panna Tiger Reserve.

Now, we know that tigers take this route when they go from Madhav to Panna and in that case if you make a reserve here in the center. Then, probably it will be much more effective than, say, creating a reserve here, where the animals do not move. So, in this case we are making use of gap analysis, we are making use of gap analysis to understand where we should be making these

reserves.

So, we try to maintain the connections. We try to enhance the connection and we try to do it in a way where we can get the larger size areas and in those locations where we do not have the sanctuaries, but we do have transit paths of animals. Now, in the case of Madhya Pradesh, the tiger is the most important animal in terms of conservation, because it is a keystone, flagship as well as umbrella species. And so, when we are focusing on tigers, we should look at the routes that the tiger takes when it moves from one location to another location. So, this is what was done to identify the locations where we can have newer sanctuaries.

Now, once we have looked at what a protected area is, how do we make a protected area and what is the importance of a protected area. Let us now have a look at the economic analysis of protected areas. When we make a protected area what is the benefit that we can provide to people so which brings us to the ecosystem services from protected areas. Now, ecosystem services are the services that are provided by a well functioning ecosystem in these protected areas.

Ecosystem services are defined as the benefits that people obtain from ecosystems, again a cost benefit approach. If you want to make a protected area you will have to convince people that it is going to be of benefit to the people. So, we have to do a computation of the benefits that we can provide to people whenever we are making a protected area. So, this is bringing us to the culmination of conservation economics and you can get an idea of how to do conservation.

It is important to make use of economics to tell people that this project is going to be economically beneficial to the people. Especially because we are living in a democracy, so it is very important to convince the politicians and the policy makers if you want to do conservation. And, if you do good conservation you are going to provide benefits to the people of your state or your country. This is why a study of ecosystem services becomes very important.

Now, ecosystem services are divided into provisioning services in which case the ecosystem provides something in the form of materials, such as food or medicines. So, if you have a well functioning ecosystem, you can get hold of certain medicinal plants or you can get hold of certain amounts of food from this area. So, this is known as a provisioning service.

Now, this provisioning does not just mean that you should allow people to get into the protected area and approve these medicinal plants. But what it is saying is that if you maintain your area as a protected area, then a number of these species will also come out in the form of say seeds and through which you will be able to get these resources for the people who are living in the vicinity. So, provisioning services include things like food and medicines.

We also have several regulating services such as the regulation of local climate, the biological control of pest populations and so on. So, it has been seen that in areas that are close to the protected areas the level of insect infestation is much lesser, because the protected areas harbor a large number and variety of birds. There will also be a large number of insectivorous birds, and these birds will provide protection to the farmlands that are near the protected area.

So, this is an example of a biological control over the pest. The farmers that live in the vicinity do not have to spend that much amount of money on purchasing insecticides. So, this is a regulating service another regulating service is the regulation of the local climate or the microclimate. So, the areas that are close to the protected areas have a more amiable climate, it does not be-

come that hot in summers it does not become that cold in winters. So, that is a regulating service in the form of climate regulation.

Then, these ecosystems also provide supporting services in the form of soil formation and nutrient cycling; they also provide several cultural services, such as recreation, educational uses and religious uses. So, these are different services that a well functioning ecosystem provides to people. We have provisioning services, regulating services, supporting services and cultural services.

And to do a valuation of these services we can make use of economic models. Now, if you remember, a model is a simplified depiction of reality, but the best thing about a model is that it allows us to do computations in a simplified manner. One such model is the InVEST model, investors integrated valuation of ecosystem services and tradeoffs an integrated valuation.

So, you are incorporating a number of variables to do an integrated valuation; valuation of ecosystem services and also of the tradeoffs that you need to make, tradeoff in terms of say if you have 100 rupees. If you spend these hundred rupees into the functioning of a protected area do you get say 105 rupees out of it or do you lose 5 rupees and you only get 95 rupees in return.

That is a tradeoff. You have certain amounts of funds every government has certain amounts of funds. And, if the government uses them in construction or maintenance of a protected area, then probably those points cannot be used in other locations, say for health care or for education sector, or for setting up of a new industry or for laying of new roads.

So, there is always a tradeoff. The InVEST model helps us to understand that if we are putting 100 rupees into the functioning of the ecosystem services. Because of making a protected area or protecting a protected area, what is the return that we get out of it. So, that is something that this model also tells us. So, this is a GIS based suite. GIS is geographical information system.

So, in the case of GIS we make use of the information about where different things are located, where the water sources are located, are they located close to the villages or are they located in the interior of the protected areas, which would mean that they are far away from the villages. So, these are the kinds of information that we make use of: where does the river flow, where are the hills, where are the mountains, where are the planes.

And, we make use of all such information because we are using the geographical information. So, this is a GIS based suite of open source software models for mapping and doing valuation of ecosystem services. It performs computations using spatially explicit data and models. So, the data and the models that we use are also based on where different things are located, they are spatially explicit.

And, the final results can be in the form of biophysical information such as the tonnes of carbon that were sequestered, or we can get the results in the form of economic information that is what is the value of that amount of sequestered carbon. So, you can ask this model to give you a result of that; that so much amount of tonnes of carbon dioxide were sequestered by this protected area in this year, or it can give you what is the market value of that amount of sequestered carbon. Similarly in the case of water resources, similarly in the case of other services such as the probating or the supporting services.

So, let us now have a look at what kinds of services we model here? The first thing or the first

ecosystem service that the protected area gives you is employment generation. Because, there will be a large number of gypsy drivers that get employment, there will be a large number of guides that get employment, there will be portals that are set up because tourists are coming to this area.

Now, when the tourists come they will require n number of services, and all of these provide employment to people. Now, what is the amount of employment that the protection that the protected area generates? Is, given as the sum of the number of man days into the wage rate. So, how many man days of employment were generated, what was the rate at which these people got paid?

So, we do a multiplication of both of these and you sum them up for all the people who are getting employment, because of the protected area. So, this is giving us a value of the employment generation. Fishing benefits; which is the sum of production into the market prices. Now, in some protected areas we do permit fishing, especially in the buffer areas.

If there is a buffer area and it is getting water from the protected area or it is a part of the protected area, and it is also getting benefited or protected, because of the activities in the protected areas, what is the amount of fish caught and what is the market price of that fish. So, when you do a sum over the production into market prices you get the fishing benefits. We compute the fuel wood benefits again production into market prices, fodder benefits, production into market prices.

So, we are doing all these different kinds of valuations. Timber benefits: how much is the amount of timber that can be extracted especially in the buffer areas. Where do we permit extraction? We do production into market prices. Bamboo benefits: production into market prices. Non timber forest produce: this includes things such as honey, lac, medicinal plants and so on.

So, in the case of non timber forest produce, you also have a market for honey, you have a market for lac, you have a market for the medicinal plants that you get out of the forest. So, here again we can do production into market prices the sum of all the NTFPs that you are getting in this area.

Gene pool benefits such as the resilience of ecosystems and avenues for future use of biological compounds, or other products computed using the benefit transfer method. Now, what we are saying here is that if you conserve an area as a protected area, you are making the ecosystems more resilient.

Which means that if there is a release of pollutants into this area your ecosystem will not collapse that easily, then an ecosystem that was not given this protection. Because, as we had seen in the case of large infrequent disturbances, if a biological community is already disturbed or is already half disturbed and you give it a single disturbance and it will collapse.

But, when you are maintaining a system as a protected area you maintain the organisms in this ecosystem in the best possible state. And so, they are much more resilient to any impacts or any disturbances such as say, because of the release of pollutants or because of an oil spill or because of a forest fire. So, we get genepool benefits in terms of resilience of ecosystems.

You also have avenues for future use of biological compounds and their products, which means that if we have a new disease that comes up. Then, we will have to look for medicines; we will

have to look for those compounds that can help us fight those diseases. Now, a number of plants and animals have certain compounds that are known as metabolic compounds.

Now, these compounds can play a role in protecting us against diseases, a good example is the quinine that we get from the bark of cinchona trees. Now, quinine is something that the plant manufactures not because it is an anti malarial, but because it provides a certain degree of protection to the plant, other animals do not eat that plant insects are less able to invade into this plant. But, then because this plant produces quinine and if humans get malaria, they can make use of this bark to extract quinine to work as an antimalarial drug.

And a number of medicines such as artemisinin are also derived from different plant products. Now, if we have a large amount of biodiversity, there is a greater chance that we will have access to one or more of such compounds in the future when we need them. So, these are genepool benefits: the benefits that you are getting, because you are maintaining a good genepool and a good biodiversity.

Now, these kinds of benefits are computed using benefits transfer method, which is a method to estimate the economic values for ecosystem services, by transferring available information from studies already completed in another location and or context. What this means is that suppose in a protected area in some other country or in some other part of your country calculation has been made; to make evaluation of the kinds of benefits that we get to make an economic evaluation of the benefits that we get, we can make use of such studies to incorporate the results of the analysis that was done there into our protected area. That is known as a benefits transfer method. We can compute the valuation of these genepool benefits using the benefits transfer method. You do not have to do a valuation at each and every protected area, but in certain protected areas you can do a more intensive valuation and you can make use of those results in your protected area of study. Then, we can find out carbon sequestration benefits which is the amount of carbon that has been sequestered multiplied by the market prices, or we can even make use of the social cost of sequestering this carbon.

Carbon storage benefits which is again total storage into the social cost of carbon. What is the social cost? The cost of impacts that is caused by the emission of carbon dioxide. So, what we are asking is if we did not sequester this amount of carbon, if we did not store this amount of carbon then this carbon would have been released into the environment. It would happen there in the atmosphere, it would have played a role in global warming and in climate change.

Now, because of climate change, because of global warming, there are a number of extreme climatic events. We are seeing more floods, more droughts, and things like that. Now, what is the social cost, what is the cost that people are suffering, because of that amount of carbon that is there in the atmosphere? That is the social cost of carbon.

We can do carbon storage benefits as total storage of carbon multiplied by the social cost of carbon. We can look at water provisioning benefits. What is the amount of clean water? That is given by this protected area multiplied with the market prices. We can look at what are purification benefits, which is the water that is purified by a protected area multiplied by the average cost of treating water.

Or we can look at soil conservation and sediment retention benefits. The amount of erosion that

was avoided by this protected area multiplied by the cost of damage that was avoided, we can look at nutrient retention benefits.

The amount of nutrients that were retained multiplied by the cost of artificial fertilizers, that would have been required if you were not retaining these nutrients. Biological control of pests computed using benefits transfer method, moderation of extreme events benefits, pollination benefits, nursery for various species benefits.

Habitat for various species benefits, cultural heritage benefits, recreation benefits, air quality benefits, water assimilation that is being done by the protected areas, what is the benefit because of that. What is the benefit from regulation of climate? We can use it; we can have a look at all these different ecosystem services that are being provided by the protected area and do an economic valuation of that.

Now, what sorts of results are obtained? So, if we look at the valuation of Panna Tiger Reserve, we are getting flow benefits of around rupees 70 billion in a year of which direct benefits are 0.78 billion, indirect benefits are 53 billion option benefits are 15.65 billion stock benefits, critical ecosystem services kinds of services.

So, in total what we are getting is that we are having an investment multiplier. So, we can add up all of these different benefits and then we can figure out what the investment multiplier is. Now, what is an investment multiplier? An investment multiplier asked the question that if the government, or if the public spend 1 rupee into the protected area what is the return that they get out of it.

So, suppose the government invests 1 rupee in the health care sector, then people are more healthier if they are healthier then there is an increase in the economic output. What is that level of economic output? What is the bang for the buck that we are getting and what are the benefits that we get? So, for any investment we can look at the investment multiplier. And here we are observing that the investment multiplier, in the case of Panna Tiger Reserve, is as high as 1939.36.

Now, this is especially because if you have a protected area, there are hardly any costs involved, because you only have to maintain that area's minimal level of protection and minimal level of habitat interventions. But, then nature does everything else for you. So, it is a very good investment multiplier meaning that it is a very good investment opportunity for any economy.

That is all for today. Thank you for your attention. Jai Hind!

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Module 12
Case studies
Lecture 2
Economics of Environmental Disasters - I

Namaste! We carry forward our discussion on Case Studies and in today's lecture we will have a look at the Economics of Environmental Disasters. What is a disaster? A disaster means a catastrophe, a mishap, calamity or a grave occurrence in any area, arising from natural or man made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property and or damage to, or destruction of environment. And is of such nature and magnitude has to be beyond the coping capacity of the community of the affected area. So, what it means is that a disaster is something that is a grave occurrence in any area and it may occur because of natural causes or manmade causes.

So, we can have natural disasters or we can have manmade disasters. Good examples of natural disasters are things like floods or hurricanes or volcanic eruptions. Good examples of manmade disasters are industrial disasters. So, you can have natural disasters or man made disasters and disasters may also be caused by accident or negligence.

Now, a common property of these disasters is a substantial loss of life or human suffering or damage to and destruction of property or damage to or destruction of the environment; that is a common feature is that either human lives get lost or there is human suffering. In certain cases people might get sick; people might get injured. Even though they are not dead because of a disaster, it leads to a very huge amount of human suffering because of a disease or because of, say, an injury.

Or in certain cases, there might be a destruction of property or a destruction of the environment. And these are of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area; that is it overwhelms the resources and the coping capacity of the local community and in that case we will call it a disaster.

Now, disasters can be natural disasters such as earthquakes, landslides, tsunami, flood and so on or we can have human made disasters such as industrial accidents, oil spills, war, terrorist attacks and so on. So, there are all these different kinds of disasters. Now, in the case of the management of disasters; we have certain definitions.

The first is risk; risk is the effect of uncertainty on the objectives or a combination of the probability of an event and its consequence. So, risk is a combination of probability of an event and its consequence. Which results in an impact on this uncertainty on the objective of normal management.

When we talk about risk; we talk about what is the probability of such a disaster happening, what is the probability of a flood in your area, what is the probability of having a tsunami in your area and should there be a flood; what would be its consequence? Now, consequence would depend on whether your area is, say, up lying or low lying, how much is the given density in that area, how much are the infrastructure levels in that area, and what is the quality of infrastructure.

So, there are a lot many things that are involved. This is a combination of the probability of an event such as the probability of a flood and the consequence of that event; that is to say the consequence of a flood in your area. Risk perception is the way in which a stakeholder views the risk, based on the set of values or concerns.

So, it depends on the stakeholders needs, issues and knowledge. It is the way in which a stakeholder views a risk, based on a set of values or concerns. Now, for a single risk; the level of perception might be different in different stakeholders. Because there are people who might not perceive the risk at all because there could be people who just do not think that there could ever be a flood in their area. There are a number of people who say that there is absolutely nothing like climate change that is happening.

These people are completely oblivious to the occurrence of the risk. On the other hand, if somebody is more knowledgeable; then they would have a very different perception of risk; they would not think that this risk of a flood coming to the area is because of a previous karma.

But they would think that this is because of, say bad management of the water resources in the area. So, the perception of risk varies with different stakeholders and it is the view or the way in which the stakeholder perceives the risk, based on a set of values or concerns. A person who has a lot to lose in a disaster would have a very different concern from say a bystander. So, a person who is living in India will probably have a very different view of say drought in Australia than an Australian; who is living in Australia.

Which is why the perception of risk varies between different stakeholders. Then, we have risk management; so if there is risk; it has to be managed. Risk management is the coordinated activities to direct and control an organization with regard to risk. So, it is a set of coordinated activities; so it is not a one of solution it is a set of coordinated activities that all aim to direct and control an organization with regard to the risk. So, in the case of risk management; we will talk about how we quantify the risk.

And what are the kinds of steps we should be taking to minimize the risk and should the disaster occur, what are the kinds of preparedness that we would make so that the amount of risk is minimized. Next we have the risk management system which is the set of elements of an organization's management system that is concerned with managing the risk. So, for instance if there is a disaster or there is a probability of a disaster; who is going to respond? Do we have a set of people who are trained in this response?

This is known as the risk management system; the set of elements of an organization's management system that are concerned with managing the risk. Then, we have risk source: the element which alone or in combination has the potential to give rise to others; an element which alone or in combination has the potential to give rise; to a risk. For instance, if there is a dam; that is made in an area that has been suffering from earthquakes.

So, this dam is now a source of risk because the dam would hold a very great volume of water which will have a very large amount of mass. Now this amount of mass will exert a downward force on the tectonic plates that are there in that area. Now, because of that the earthquake probability might go up or suppose an earthquake occurs.

And if the dam fails, in that case a huge area will get inundated; it will be flooded. So, this dam is now a source of risk in that area both because it can increase the occurrence of earthquakes and also because should an earthquake occur; it would lead to very great amounts of damage. This is a risk source, an element which alone or in combination has the potential to give rise to a risk. An event is defined as the occurrence or change of a particular set of circumstances, even if the occurrence of a circumstance or changes in a particular set of circumstances and consequence is the outcome of an event that affects the objectives. So, you can have an event of flood in which case there is a flood and the consequence could be things like loss of life or damage to property or damage to the agriculture of the area. So, it is impacting the normal management which is why it becomes a consequence; it is the outcome of the flood, so it is the outcome of an event.

Then, we have likelihood; likelihood is the chance of something happening. If you live in an area where you have a river, then there is a likelihood that there could be a flood. If you live in an area that is very dry and perhaps it rains say just a few millimeters in a year, then probably the likelihood of having a flood is much less.

So, likelihood is the chance or the probability of something happening; control is a measure that maintains or modifies the risk. When we have a risk and we try to control the risk, it is a measure that maintains or modifies the risk and in a number of cases it tries to reduce the risk.

A stakeholder is a person or organization that can affect, be affected by or perceive themselves to be affected by a decision or an activity. Stakeholder is a person or an organization; so you can have a person or you can have an organization and their role is; they can affect a decision.

They can be affected by a decision or they perceive themselves to be affected by a decision or by an activity. If the government is deciding to build a dam in your area; then the government is one of the stakeholders because they are doing something. If you live in that area and you can get affected by this dam; then you are also a stakeholder.

And if there is say an organization that caters to the well being of wild animals in your area; so and they think that because of this dam the wild animals will have a negative consequence, they will suffer a negative consequence and they perceive that they, that their activities will also get affected because of the construction of this dam, then all of these are stakeholders. If there are people who can tell the government that this should be the height of the dam or this should be the structure of the dam.

Then they are also the stakeholders. The experts are also the stakeholders, the media is a stakeholder. So, stakeholder is all those persons or organizations that can affect a decision or activity, that can be affected by a decision or activity or who perceive themselves to be affected by a decision or activity; they are all the stakeholders.

How do we manage risk? What are the principles of risk management? Well, the first principle is that risk management is integrated; it is an integral part of all organizational activities. It is not a

one of solution, it has to be there whenever you are doing any activity in your organization. So, whenever we are building a dam; we have to think about the kinds of risks that it might pose and we have to incorporate all these risks and the management of those risks in the construction of the dam.

Risk management always has to be integrated; it has to be structured and comprehensive. A structured and comprehensive approach to risk management contributes to consistent and comparable results. It is not that when you make one dam, you will have a different set of results; when you make another dam, you will have a very different approach to making this dam. It has to be structured; it has to be comprehensive so that it can be applied to different circumstances.

But at the same time you also need certain customized solutions. The risk management framework and process are customized and proportionate to the organization's external and internal context related to its objectives. So, risk management also has to be customized, it has to be inclusive, appropriate and timely involvement of stakeholders enables their knowledge, views and perceptions to be considered. This results in an improved awareness and informed risk management.

Whenever we are taking a decision; it is always prudent to include all the stakeholders. Whenever the government gives permission for a dam to be made, then before the construction ever begins; people have to go out and talk to all the different stakeholders that are there.

What are their perceptions, what are their fears and all those perceptions and fears, views; they have to be incorporated in the project document. So, risk management has to be inclusive; you cannot take decisions on behalf of others, you have to include them whenever you are making a decision.

Risk management is dynamic because the risk can emerge, change or disappear as an organization's external and internal context changes. So, risk management anticipates, detects, acknowledges and responds to those changes and events in an appropriate and timely manner.

What we are saying here is that the risks may change with time. When for instance, you set up an industry and the whole of its surroundings is a barren land; then the sort of risk is very different than at a later point of time, when suppose the town has extended itself, the town has expanded and it is now right on your doorstep.

Because in the earlier situation, when it was a barren land and people were not living there; in those circumstances, there was hardly any risk of loss of life or property should any industrial accident occur. But when the town has expanded and has come to you; then the risk would be very different because if any industrial accident occurs.

Then there will be a huge loss of life and property. Now, in this case the organization that is the industry is not doing anything to change the risk, but the external conditions have changed to such a level that the risk has changed. In certain other conditions, it may be a result of the organization's internal dynamics that the risk changes.

For instance, if there is an industry and currently it has all new equipment; everything is computerized, everything is working properly, but then because of bad management over time; it is possible that the equipment now does not work in that way. Now, in such a scenario; you even though the outside environment remains the same, because the equipment is now failing; so that

would increase the amount of risk that an accident could happen because of which the risk management needs to be dynamic.

So, it has to change; if the equipment becomes old, you will have to make changes to your risk management strategy. If the town expands and comes to your backdoor, you will have to make changes to the risk management strategy. Then risk management should always incorporate the best available information.

The inputs to risk management are based on historical and current information, as well as on future expectations. When you are setting up the industry; you should know if any similar industry elsewhere in the world has resulted in any industrial accidents. If so, what kinds of accidents, how many people were involved, what was the response of management and was the disaster contained in a set period of time or not? So, you have to look at the historical context.

You have to look at the present quantities which is the best available way of mitigating the risk that the industry can propose to the surroundings. We also have to incorporate the information about the future set of events. How fast is the town expanding, how soon will people be able to reach into this area, is there any other industrial facility that is supposed to be set up nearby? Because they will all change the total amount of risk that the industrial setup is posing to the surroundings.

It has to be based on the best available information. Risk management explicitly takes into account any limitations and uncertainties associated with such information and expectations. Information should be timely, clear and available to relevant stakeholders. So, when we say that it explicitly takes into account any limitations and uncertainties associated with such information; what are we saying? Is that if you do not know how fast the town is going to expand.

Or how soon are people going to come near your industry? Then, you have to acknowledge this risk and work on a precautionary principle approach which means that if there is say a 10 percent probability; that people would have reached to your industry, then the precautionary approach would say that let us assume that this 10 percentage or probabilities going to happen and let us make all the arrangements. So, if there is a limitation or uncertainty that is associated with this information.

Because risk management is based on the best available information; you have to incorporate any limitations that you are facing. Risk management is based on human and cultural factors. Human behaviour and culture significantly influence all aspects of risk management at each level and stage which means that in certain societies.

There people might be more risk averse, in certain societies people may be less risk averse. Now, whenever you are making any decision; you have to incorporate what is the level of risk aversion of the surroundings, of the people in the surroundings, what are the other risks that these people are already facing, and what are the cultural aspects?

All of these have also to be incorporated into risk management. And risk management is based on continual improvement through learning and experience which means that if there is say a new study about how a risk should be managed and if it is applicable; then probably it should be implemented in the current scenario.

So, it has to be continuously improved; it is not that once you have made a risk management doc-

ument and once you have implemented it, then there are going to be no further changes; there has to be a continuous process of improvement in the risk management strategies in any organization.

The process of risk management comprises communication and consultation, monitoring and review and establishing the context, risk assessment and risk treatment. What happens in the case of a good risk management strategy is that we begin by things such as communication with the stakeholders, consultation with the stakeholders and getting to know everything that can be known about this particular risk. Then, we establish the context.

What is the site of the place where the industry is going to be set up, what is the setting of this area? In this context, what is the assessment of the risk, what is the possibility that things may go wrong and what is the possibility that we will have certain consequences because of something going wrong; so that is risk assessment.

It includes identification of the risk, analysis of the risk and evaluation of the risk. And then we make a strategy for risk treatment; how are we going to reduce this risk? And in all these processes; there is a continuous communication and consultation with the stakeholders.

Because remember we cannot take decisions on behalf of others, we have to incorporate every stakeholder in all the steps of risk assessment and risk management. There is a continuous process of communication and consultation and in all these processes; there is also a continuous monitoring and review.

When we talked about risk identification; did the person who was doing the risk identification; did he or she include all different kinds of risks that he or she should have looked at or perhaps they missed out on certain risks. Now, who is going to tell this; if there was no monitoring and review mechanism.

A monitoring and review mechanism is there during the risk; identification stage, it is there during the risk assessment stage because it is possible that the person who is doing the risk assessment probably comes up with a very low assessment. It has to be there when the risk management strategy is being implemented.

Because they could be lacunas in the implementation of the risk management strategy. In all these steps; there is a continuous monitoring and review. Now, this is a theoretical framework on which risk management works and this is how it should be managed, but then this is not always how things are managed in practice.

Now let us have a look at what happens if the risk is not properly managed. What are the kinds of reasons because of which a risk is not managed properly and what are the consequences?

We will have a look at certain case studies; the first one is the Minamata disease. Now, the Minamata disease originates from a village that is known as Minamata in Japan and this village was traditionally a fishing village. It was full of fishermen whose main source of livelihood was fishing in the nearby sea.

In 1932, a local industry by the name of Chisso factory; it begins the production of acetaldehyde and it uses a compound of mercury as a catalyst for the reaction. Now, once the reaction is done; what happens to the spent mercury, the spent catalyst; it is now of no use to the industry. Now, the industry could have done 2 things; one process this catalyst because whenever you are throw-

ing something out as a waste, it might have a negative consequence on the environment. The industry could for instance have spent money on the processing of this spent catalyst that was having mercury inside it. But it did not do that; what it did was it just dumped the spent catalyst into the sea. Now, here again it is important to note the importance of externalities.

If the industry had spent resources on the processing of the spent catalyst; then it would have reduced the contamination of the surroundings, but it would have cost the industry; whereas, if the industry just threw it out into the environment, then the industry could increase its profits.

It is in the short run when it does not have to pay for damages and the damage is felt by the people who are there in the surroundings. It is not experienced by people in the Chisso factory, but by people in the surroundings in whose area they are throwing this waste. So, the spent mercury catalyst is dumped into the sea.

Now, by 1950; so it is now 20 years or roughly 20 years to the time when they start dumping off the catalyst; the spent mercury catalyst. Now, by the 1950s it is known that in a number of locations, fish are found floating in the water. So, these triangles; these white colored triangles are all those locations in the surrounding where fish are dead and they start to come to the surface, they start to float on the surface. Now, this is a disease that nobody had seen before; another thing that happens is that the cats in the area.

So, this is the water body and all over the water bodies; we are finding that the fish are dying. Inland, what we are finding is that at all these locations we are finding strange symptoms in the cats. Symptoms such as this; by 1952, people are starting to report that the cats are committing suicide.

The cats have a large number of neurological deficiencies; a large number of neurological diseases. So, they go on repeating an activity again and again and again and these cats are so highly depressed and they are so diseased because of these neurological symptoms that at times they jump from a cliff or they die off.

So, there are a number of instances of cats committing suicide in this area. So, this is when people actually started to look at this particular phenomenon. What is so special about Minamata is that the cats have started to commit suicides. What is suspicious is that the fish are dying and floating on top of the water.

Then in a short time, we start observing symptoms in the human sense value. So, the humans also start to show very similar symptoms. So, their hands, their body parts are now showing symptoms such that their joints are getting affected; they are showing repeated movements and the number of the human victims is increasing.

And by the year 1959, the scientists and the doctors have discovered that mercury is one of the reasons. What are the kinds of symptoms that we observe in humans? Disturbance of sensation, superficial sensation and deep sensation; the people are not able to sense properly, showing that there is damage to the nerves.

There is a constriction of the visual field in 100 percent of the people that is they are not able to see properly. There is dysarthria; arthrosis joint, dysarthria is a deformation in the joints such as what we have seen here. So, there is this dysarthria in a large number of patients; there are disturbances of coordination; people are not able to walk properly, people are not able to do any activ-

ity properly. We have things like impairment of hearing, tremors, changes in salivation, mental disturbances.

These different kinds of symptoms are noted; it is observed that a number of these symptoms arise because of neurological problems and it is known now that mercury is one of the reasons or the primary reasons. We will start observing damages in the brain. If there is a postmortem, people would find that the brains are having holes and importantly cat number 400 dies; what is cat number 400? One of the scientists; what he did was he took cats and he started feeding them with the residue that was being thrown by the company into the sea water.

Once he started feeding the cat; he was able to develop all these symptoms very quickly in the cat and so it was proven that it is because of this waste material that is being dumped that we are seeing all these different kinds of neurological symptoms. And in 1959, this cat died because of all these neurological symptoms.

Then in 1959, demonstrations began against the company and what the company does now is that they install equipment that supposedly treats the waste. But, here again what the company did was that they did not actually install a machine that could process the waste efficiently.

It was more of an eye wash because there were demonstrations; so, the company said ok we have to do something. So, they did something, but that was the; that was not the most efficient thing. So, the company still carried on dumping the waste into the sea even after knowing from one of its scientists that this waste was causing the neurological symptoms in the animals, in the fishes, and in the humans in this area. And because the company did hardly anything to stop these wastes; ultimately in 1975.

This whole area had to be dressed which means that all the sediments in the sea had to be excavated, processed and thrown to some other location so that the level of contamination goes down. Now, just think of the amount of money that a company would have to spend to process its waste.

Well, when the company is throwing the waste; the waste is in a very concentrated form and it is easy to treat. Once we have dumped the waste into the sea; it has spread to such a large extent over such a large area that now you have to dredge the whole of the sea in that; in the surrounding areas; so the cost goes up like anything.

Then, if you look at the environmental damage that the company did; a payment of 12.63 billion yen per year; now billions of yen per year are projected for health damage compensation, sludge treatment and damages to the fishery. And if we look at the human cost.

By the year 2005, total number of officially certified patients around 3000, recipients of the medical task of the comprehensive measure of Minamata disease; since 1992, around 13000, patients manifesting health effects of methyl mercury that were recognized by the ruling of the supreme court in 2004; 58 and applicants for certification before the judgment greater than 3300. So, what we are observing here is a huge cost. In terms of human health, human life, animal health and environmental damage.

And all of these walls were preventable had the company just treated the waste before throwing it out into the sea. So, this is what happens, when risks are not properly managed. The kinds of tragedies that we can observe, when people just contaminate the environment because it is just an

externality, just a cost cutting measure.

Another example is the Aral sea. Now, this is an image from 1974; that is telling us how big this Aral sea was. It was formerly the fourth largest lake in the world with an area of 68000 square kilometers. In the 1960s, the Soviet government decided to divert waters of Syr Darya and Amu Darya, these are 2 rivers that were providing water to the Aral sea. And the soviet government decided that the water of these rivers can better be used for agriculture.

In the 1960s; the Soviet government decided to divert the waters of Syr Darya and Amu Darya into the desert to enable cotton production. So, the water that is getting into the lakes is now diverted. A large system of canals was created; due to lack of water flowing into the Aral Sea, it started to shrink.

The lake earlier was in a dynamic equilibrium; the amount of water that it was losing out because of evaporation was roughly equal to the amount of water that was flowing inside. So, it was losing out as much water because of evaporation say because of some amount of seepage into the soil and so on.

But the amount was largely balanced by the amount of water that the rivers were bringing in. Now, if you stop the flow of these rivers and if you divert the water; then the input to the lake stops, but the output because of evaporation or because of seepage continues as it has. So, now, you are not letting water enter into the lake and so the size of the lake starts to shrink and the salinity increases from around 10 grams per liter to above 300 grams per litre; killing off most of the fish.

Now, we have observed in one of the earlier lectures that every organism has a range of tolerance for different components of its environment. Now, fishes also have a range of tolerance for salinity. When it becomes too saline the fishes are going to die off because it is now no longer fresh water, it has now become very salty water.

The salinity increased from 10 grams per liter to above 300 grams per liter killing most fish. Pesticides and fertilizers from the cotton fields reached the Aral Sea; increasing pollution and killing off most of its natural life. Not only was the salinity increasing, but at the same time; the pesticides and the fertilizers were also reaching into the sea and that was also causing a lot of contamination to the sea. Then cancer rates, infant mortality and diseases in humans have gone up.

Now, because the humans that are living in the surrounding of the Aral sea; now remember that the Aral sea was one of the largest lakes and it was a very beautiful tourist location. There were a number of resorts, there were a number of people who were fishing in the Aral sea. Now, when the Aral sea starts to shrink and when it becomes more and more contaminated; then the surrounding water, the fresh water that people are using also starts to get more and more contaminated.

Because all those pesticides and fertilizers that are getting drained into the sea; they will also be into the groundwater level and so we start to observe that the humans in the surrounding that were a very substantial population; we start observing a number of health problems in those women as well. The rates of abortions go up, diseases go up, cancer rates go up, infant mortality goes up. All these different kinds of diseases and symptoms are now increasing in this area.

Dust storms and salt deposition impacts the local communities who have already lost employ-

ment. Now, when the sea starts to shrink; then more and more land becomes exposed and whenever there is any storm; then all of this all the dust of this land would get airborne and it would spread.

Similarly, this lake has now become very saline and so the shores where the salt is getting deposited; that salt will also become airborne whenever there is a storm and it will get into the houses, it will get into the equipment of the people who are living in the locality.

On the one hand the tourism industry is gone because it no longer is a pristine water area, the fishery industry is gone because all the fishes have died, the level of diseases have gone up because the water is contaminated. Then, we start observing environmental damages because of this contaminated water and highly saline water and exposure of the soil through the winds. So, we start observing dust storms in the area and we also start to observe climatic changes.

Since the moderating effect of the water body has been lost. So, near any water body; we have moderate temperatures, it does not become very hot in the summers; it does not become very cold in the winters because of the moderating impact of the water body now that the water body is gone.

We also start to observe a much changed climate with more and more extremes. So, if you look at the hydrology of this area; the annual water balance changes like this. 1911 to 1960 that is before the expansion of agriculture and before the diversion, the blue is showing us the river inflow, the yellow is showing us the net evaporation. So, roughly the river inflow is equal to the net evaporation. The area is also getting certain water from ground and there is a small surplus that we observe.

The surplus is very close to 0; so roughly the Aral sea is being maintained in the same size, but now after 1961, the inflow has gone down. So, the inflow from here becomes this, but the level of evaporation; it roughly remains the same. Why? Because of dimming of the river you are reducing the inflow, but because the lake is still of roughly the same size; so the evaporation is roughly the same. But then from this point onwards, we start to observe a change in the net evaporation as well.

What we are observing here is that over the years from the 1970s to 2005. What we are observing is that the level of evaporation is also going down which is telling us that the size of the lake is also going down and at the same time; the river inflow has also reduced substantially.

And so, earlier while we were having a net surplus through a small surplus, but a net surplus of water that was entering into the lake. Now we are starting to observe a huge deficit. So, in the 1980s and 90s, there was a deficit as large as 30 cubic kilometers per year which means that in 1 year. The amount of water that is being lost from the sea is 30 kilometers multiplied by 1 kilometer in height and 1 kilometer in width. So, that is the amount of water that the Aral sea is using every year and what does that loss look like?

This is the image that we saw in 1974; by the 1980s; so this is the image from 1984 and we can observe that, this was 74, this is 84; it has already shrunk by a large amount. But then, over the years; it goes on shrinking even further, this is the year 2000, this is 2008. So, all these areas that were earlier the Aral sea are now gone; this is 2016.

Something that was as big as this in 1974 is now as small as this. So, when people were begin-

ning to divert the waters of the Syr Darya and the Amu Darya river for agriculture, especially cotton cultivation; they did not foresee the kinds of impacts it would have on the nearby Aral sea. Because had they known that it is going to cause this greater damage to the Aral sea probably they would not have done this. Even though the cotton cultivation went up; for it for the time being, after a while it again went down and in that time period the tourism industry was gone, the fishing industry was gone.

The local people, quite a lot of them have migrated out. The people who remain are diseased and they are suffering from the vagaries of nature because of extreme climatic events and also because of a huge amount of salt and dust that is getting into their houses and into their equipment. This is what happens when risks are not managed properly and this all happened because people were looking at the short term benefits and not the long term environmental damages.

The third case study we will look at is the Bhopal gas tragedy in our country. So, the Bhopal gas tragedy begins with the plant of Union Carbide; so Union Carbide; an American corporation, had an Indian subsidiary and they set up a pesticide plant in the city of Bhopal.

And it was healed as one of the shining examples of the new India because in the; in the newer India, in the modern India more and more amounts of pesticides would be used in the case of agriculture so that we have bumper harvest. Now, the area that was chosen for this company; it was very close to the city limits and in a very short period of time, the population had or the city had grown to such an extent that people were living right next door to an industry.

This is an industry that is dealing with toxic materials because it is making pesticides. Now, what happens if these toxic materials ever get out? It will observe a large size mortality. So, this is a risk that should have been perceived at that point of time, but sadly it was not. So, it began with this shining example of new India; so this is the Union Carbide factory. And these are the kinds of advertisements that the Union Carbide was putting in.

If we have a look at the location of the factory. So, this is the upper lake of Bhopal and this is the location of the Union Carbide plant. As you can observe, all this area is the area where people live; here you have small bits of forest and agricultural lands, but this is where people live.

It is said that when the plant was set up; the human population nearby was not at large, but then when the plant was set up it provided employment opportunities; so a number of slums were set up near the plant. As we saw, risk management changes with time.

And on the night of December 2 and 3, 1984; the methyl isocyanate gas was released from this plant, it led to a large number of deaths and blinding of people. It was heavily documented because it was the worst industrial disaster in the history of humankind; 2500 people would die, it would injure thousands.

And we find documentation in all major media. So, this is the BBC, this is The Hindustan Times; on that particular day, the death toll was 1200 and it was rising; this is The Indian Express. So, this is something that has been very well documented and very well studied and the impacts of the release of methyl isocyanate on that night, they still continued. People are still disabled, people are still sick; now the basic question is, why did we have such a tragedy?

The Union Carbide happened to be a very established name, a very respected name. So, how was it possible that we just could not foresee the risk and we could not manage the risk, how was that

possible even? So, after this documentation; there were a number of studies. What went wrong? And we are interested in knowing what went wrong economically; well the insecticide named Sevin that they were manufacturing was not selling as expected. Only around 20 percent of the plant capacity was being used. So, everything begins from an economic point of view; the cause of this disaster was that the insecticide was not being sold at that large a quantity at that larger volume that the industry was expecting. So, only 20 percent of the plant's resources were being utilized.

When that happens; the cost that the company had put up in setting up of the plant that was not getting recuperated fast enough. Well it was still showing a profit mind you, but it was not showing profit to that large in extent or that fast that the company had expected to see.

Now, when only 20 percent of the plant capacity is being used; the plant was shut down for maintenance. And because it was only 20 percent of the plant capacity being used, they also did a large number of cost cuttings to maintain the profit of the company; cost cutting such as the excess methyl isocyanate gas.

Now, methyl isocyanate was the gas that got released on that particular day. Now, this is such a toxic gas that it is never stored in the company. Generally, the standard procedure is that when you make the methyl isocyanate gas; you make it in very small quantities and then you use that quantity so that you do not have to store it in any large quantity.

But because the company was going through a cost cutting measure, what they did was that methyl isocyanate was made in larger batches and it was stored because they wanted to increase the profits, they wanted to reduce the cost; so what was done was that the MIC was manufactured in larger quantities and it was stored. So, why run the equipment again and again? Then, not only was it stored in the tanks; it was stored above the requisite capacity.

So, the tank from which the gas was leaked, it was 75 percent full when safety procedures required that half of it should be kept empty to serve as buffer for heat; that is when the when this gas has been stored in a tank, then it is being stored above the capacity because again why run the equipment again and again to manufacture the gas.

They were trying to maximize the storage of the tank of the gas, but when it was being stored; the refrigeration unit was also shut down which raised the temperature. Now, MIC had to be stored below 0 degrees Celsius and the; what we are observing here is that the refrigeration unit was shut down. Why was it shut down? Well, why waste electricity? It is all profits. So, to maximize profit, the refrigeration unit was also shut down.

Then, impurities were getting in because of lack of maintenance and leaky walls. So, if there was a leaky wall; then the company officials did not bother to get it changed. Why? Again, cost cutting; maximization of profit, if there is something that is not working; why spend money on fixing it?

So, impurities including water were known to cause runaway exothermic reactions and this is actually what had happened on that day. Sensors were either not installed or did not work; why? Cost cutting. There was a lack of computerization; why? Because if there is a plant that is only working at 20 percent of its capacity; why spend money to modernize the plant; so, no computerization here.

The gas scrubber that used caustic soda was shut down. Now, why do we need a gas scrubber? Because if there is any gas that gets leaked from the industry, then it should be neutralized; so there are different ways of neutralizing a gas. One is that you treat it with certain chemicals such as caustic soda, second is that you can burn the gas, third is that you can make it pass through certain other chemicals that will absorb the gas but in this case, the gas scrubber or shut down; why?

Well again to maximize profits, to bring the cost down. The decontamination towers and the flares were shut down. Now, these flares are something where there is a big tower on top of which a flame is always burning so that if any amount of gas gets leaked, then that gas will get burnt in that flame. But, then these flare towers were also down; why? Because, why waste money in lighting up a flare tower? Water spray to reduce the temperature and neutralize the gas did not reach far enough of the stack.

So, we are observing a large number of deficiencies; then we talked about keeping the stakeholders in the loop. Now, in this case there was a lack of emergency plans and training, the locals were not apprised and drilled about safety procedures when sirens sounded and the locals just thought; it was a shift change.

Now, when you are manufacturing something that is as toxic as MIC, the locals or the stakeholders; they should have been kept in the loop. And a good way of keeping these people in the loop is through regular communication. Now, if you will remember when we talked about risk management; we were talking about communication at all different points of time. So, in this case what we can observe is that there was hardly any communication with the locals.

There were hardly any drills on what to do if this gas gets leaked? What are the kinds of emergency precautions that we should be taking? There was no such training, there was no such planning and there were. So, many accidents occur regularly in the plant due to the faulty maintenance that sirens were sounded regularly reducing their impact.

So, what was happening was that because of these leaky walls because of equipment that was not being maintained properly; there were so many accidents regularly that now people had gotten accustomed to the siren blaring. So, they just thought that ok it is a routine affair, there is nothing to be worried about. Safety equipment such as gas masks, oxygen cylinders etcetera were lacking; again why waste money in buying these safety equipment in a plant that is not running to the full capacity.

Technical workers were laid off; again this is a cost cutting measure, why use technical workers whom you have to pay more when you are not earning that much amount of profit. So, the technical workers were laid off and in their place; non technical staff was handling the equipment. Now, these non technical staff would hardly know what to do in such a dire situation.

And no citizen watch group was groomed and none existed; again when we talk about stakeholders, this was the level of stakeholder participation. So, when there was the release of this gas - now, this release happened because in one of the tanks water got in because one of the walls was leaky and when the water gets in; there is an exothermic reaction. The tank is already above the stipulated level of capacity and it is kept much warmer than is desired.

It had to be kept refrigerated at 0 degrees so that if even water entered into it; then the then the

whole reaction would be cooled down, which is why you need to always keep the refrigerator on in this case, but the refrigerator was off; so there was no cooling that was happening.

So, there was an exothermic reaction; the pressures increased, and the tank failed. So, when the tank fails; the gas gets out, when it gets out; it could have been neutralized by the chemical scrubbers or it could have been neutralized by the flares in the flare tower; they were not working.

The sirens were not working, there were no sensors. So, people did not know about such a mishap that was happening. If the sensors were installed, especially things like temperature sensors, then we would have known much before that there was some exothermic reaction happening, but then there were no sensors.

There was no computerization and this gas when it was getting released out, then we did not have the equipment to even pour water then bring its temperature down or at least dissolve some of the gas before it gets away from leaking out. And when it gets out into the surroundings; the locals just do not know about it because the sirens are blaring every day because of the regular accidents and so everybody thinks that it is a normal affair.

And then when they are actually exposed to the gas; they do not know what to do. Now a very simple way to have to prevent the deaths would have been just to take a piece of cloth and dip it in water and place it on top of your mouth so that the amount of gas that you are getting exposed to it; gets diluted it, gets dissolved in the water and so you are exposed to less of the gas, but the locals did not even know that. So, what happened was when they got exposed to the gas.

There was such a huge choking sensation there was so much burning of the eyes that people actually tried to run away from the location. And when you try to run away; what happens is, you get outside of your home and you get exposed to even greater concentration of the gas.

Because it is not that you are getting gas inside your house, your house is much safer; outside the concentrations are much harder and all of these things can be linked down to bad management, bad planning and bad economics. So, around 500000 people; that is 500000 of people; they got exposed to the MIC class.

And we can end with this quote; the morality that pollution is criminal only after legal conviction is the morality that causes pollution. It means that the morality that pollution or spreading pollution itself is not wrong, you are only wrong when the court punishes you; that is the morality that permits the society to tolerate pollution.

To tolerate damage to the environment, to tolerate not taking proper risk management procedures and we as a society will have to suffer the consequences, if we let this morality prevail. If we do not teach ourselves and our children and our grandchildren that pollution is wrong in any way. If you do not do that only we have to suffer the consequences.

That is all for today. Thank you for your attention. Jai Hind!

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Module 12
Case studies
Lecture 3
Economics of Environmental Disasters - II

Namaste! We carry forward our discussion on the case studies and we shall be looking into the Economics of Environmental Disasters. And one disaster that we want to discuss here is The Love Canal of New York which ranks in one of the top 10 environmental disasters in the world. The story begins in the year 1894, when William T Love begins the canal building. So, Love Canal is named after this person William T Love and the idea was to develop a planned industrial city, a model city of sorts that would be having all the modern facilities and to bring water to this city, this canal was done. So, this is an old map that is showing us that this is the site of the model city and this was the proposed canal that was being made.

In the year 1903, the Hooker Chemical Company was founded and it used to make chlor alkali products and it was founded in an area very close to this proposed site. This chemical factory was developing materials through the chlor alkali process which is a process in which the brine solution is electrolyzed to get sodium hydroxide and chlorine.

Now, in this process, certain other chemicals can also get formed because the brine is not a pure salt in water solution and so different kinds of compounds can also be formed. At the same time, the industry very soon because it was profitable, it was very soon expanding into a number of other chemical industries.

Whenever we have certain chemical processes, there will be certain waste products that will be generated. Because there is a reaction that is going on, there will be certain by products. Now, these by-products need to be treated, before they are dumped into the environment.

But as in the case of the Minamata disaster, here too the people who were running this factory, they wanted to go for a cost cutting measure. So, in place of treating the chemicals, they wanted to shift to a process in which they would just postpone the treatment and they would just dump the chemicals somewhere and by that time, the idea of the plant industrial town that had dropped down.

So, even though certain portions of the canal had been dug; but the modern industrial town did not come up. The people who were looking after the waste disposal in the Hooker chemical factory decided that why do not we buy up this land that is already a dug-up land and there, we can store our chemicals.

That became an idea for the Hooker chemical corporation. So, whatever waste materials would

be produced in this plant, it would be dumped into the canal and it would be dumped in the form of barrels that were full of these chemicals. Now, with this thought, the Hooker Chemical Corporation took over the Love canal.

It took it over in 1942 and for the next 10 years, it used it as a dumping site. Now, after a while, when quite a lot of chemicals had been dumped into this canal, what happened was people started to realize that this land is now soon becoming a liability. Why?

Because there are a number of drums that are full of chemicals and these chemicals are also corrosive chemicals. So, they are heating up the drums from the inside. There is a piece of land that is dug up that is all piled up with chemicals that are there in drums and the chemicals are eating up the drums and so, on any day an accident can come up.

What would have any responsible cooperation or any responsible form done in such a scenario? They would have taken these chemicals out, probably treated them. Because just keeping the toxic materials into dumb in the drums at a site is not a solution, it is just a way of postponing things; nothing else. But what this firm did was something very preposterous, they sold this land. It so happened that in the surrounding area a new colony was coming up and the Hooker chemical company sold this piece of land, this canal to the Board of Education. The Board of Education was looking for a site on which to construct a school and these people said ok this is the site that is available, you can have it and you can have it for just 1 dollar.

Now, what is happening here? If the Board of Education was getting this piece of land for 1 dollar that should have rung a bell. There is something wrong with the site; otherwise, why would somebody give it to us for just 1 dollar. But then, these people again were looking at profit and loss, they took up this land.

If you look at the agreement that was signed, there was a caveat in the agreement. Prior to the delivery of this instrument of conveyance, the grantee herein has been advised; now here, the grantee is the board of education, has been advised by the grantor which is the Hooker Chemical Corporation that the premises above described have been filled.

In whole or in part, to the present grade level thereof with waste products resulting from the manufacturing of chemicals by the grantor at its plant in the city of Niagara falls, New York and, the grantee assumes all risk and liability incident to the use thereof. ALL RISK AND LIABILITY INCIDENT TO THE USE THEREOF. So, what is happening is that the Board of Education was told that this area is all full of chemical waste, industrial waste and it is right there on the agreement.

By this sale deed, the Hooker chemical corporation is giving up all the rights and all the liabilities on this land for 1 dollar and the Board of Education is happily accepting it. It is therefore, understood and agreed that as a part of the consideration for this conveyance and as a condition thereof, no claim, suit, action or demand of any nature whatsoever shall ever be made by the grantee, its successors or assigns, against the grantor.

Its successors are assigns, for injury to a person or persons, including death resulting thereof, or the loss of or damage to property caused by, in connection with or by reason of the presence of the said industrial wastes. It is further agreed as a condition hereof that each subsequent conveyance of the aforesaid lands shall be made subject to the forgoing provisions and conditions.

So, this agreement is clearly stating that there is industrial waste on this land and these wastes can result in injury, even death of people or damage to property and when this agreement is being signed, it is being signed on the condition that the Board of Education now assumes all the liabilities.

At the same time, there will not be any suit whatsoever against the Hooker Chemical Corporation by the Board of Education or by anybody to whom the Board of Education assigns this land and if the Board of Education later on, wants to have an agreement with anybody else. Then, this condition has to be mentioned there that there will not be any suit against the Hooker Chemical Corporation.

Here we are observing that for one the Hooker Chemical Corporation is trying to give away its liabilities; whereas, the responsible course of action would have been to treat those chemicals. So, it has dumped those chemicals, but it has never treated them. Then when it is giving this land to the Board of Education, at least the Board of Education should have been more careful and especially, when it is being written on the agreement.

Now, the thing is many people just do not read the agreements, when they are signing them and this is exactly what is happening here and when we are talking about things which are industrial waste that can lead to death, then this is not something that should be taken lightly. But this is exactly what was done in that. So, this is the caveat in the agreement.

And later on, what happened? Schools and houses were constructed on this land and here, you can notice this white residue that is coming down. So, in this aerial photograph, you can observe that this is the site on which the canal was there. So, you can see the site here.

So, this was the site and on this site, now people have constructed houses, people have constructed a school and there is also white residue that is coming up. Now, in the beginning people do not care much about any residue. If you go and purchase any new property, you will just think that ok things are fine. This is just the color of the land. But then soon enough, people started to notice a number of other things.

In their residences, people started to observe that wherever there was a basement, some black colored toxic residue was coming in and this residue was smelling like anything. So, it was smelling like industrial waste and it was sweeping in and whenever they tried to clean it up, the next day again this residue came in.

There was no release from this industrial residue and it was getting inside the homes. And now, when the residue is getting inside the homes, it means that people are now directly getting exposed to these chemicals these ways. Then, people started to observe that on certain pieces of land, holes started to appear with chemical smelling black liquids.

Now, why do we have a hole? Because remember that these chemicals were dumped in drums and these chemicals were often corrosive. They were starting to eat up the drum from inside and whenever they got a leak, the chemicals would get out of the drum. But what happens then? You have a drum and this drum is full of toxic industrial waste and this is corroding.

When it corrodes, there will be certain holes that get developed on the body of the drum. Once that happens, all this chemical seeps up. Now, the chemical is outside and inside, the area is now vacant. Now, once you have such a situation, you have a drum that is empty and this empty drum

is beneath a layer of soil which is exerting pressure.

Once that happens, the drum might collapse and when it collapses, we start to observe such kinds of holes. But then, the residents, who were taking up the properties in this brand new location, did not know that there is this chemical deep inside. So, holes start to appear, toxic residues start to rise. Here you can observe that on the ground, we are observing different kinds of residues; different colours.

Black sludge is coming on the ground. People are directly getting exposed to all of these. Waste barrels are rising to the surface. Here you can observe a barrel that has come to the surface. Why is it coming to the surface? Because again, when you have these chemicals inside and when these chemicals are getting leaned down, then these chemicals can react amongst themselves.

Once that happens, in a number of cases certain gases can be produced and gases because they have a larger volume, so they start to exert a pressure. Once they start to exert a pressure, the drum would slowly rise to the surface because it is getting pushed from beneath and this is what we are observing, waste barrels start rising to the surface.

Here are the waste barrels that you can observe that have come up to the surface. And so, this is again a collapsed barrel head and toxic waste residues that have risen to the surface. And once all of this is happening, then people start to protest. So, the Love Canal Homeowners Association protest targeting the federal government was held outside the Niagara Falls, New York, Department of Health building.

Now people are starting to hesitate. They are asking what is this residue that is coming into our homes; they are asking that ok, the site where this school is constructed, all these drums are coming to the surface and the pupils are playing with these drums, they are playing with these chemicals.

Now, if there are these industrial chemicals or these chemicals that have such strange smells and our children are playing with these chemicals, won't they have a negative impact and if there is a negative impact, what is the government doing? This is what they are asking. Now and when such a thing happens, the government did an environmental sampling. An environmental sampling was done in all of this area. And this is the result of the kinds of chemicals that were identified.

Benzene, which leads to things like narcosis and skin irritation. This is an acute effect. Acute effect is something that happens quickly. For any of these compounds, we have certain acute effects which happen in a short period of time and we have certain chronic effects that happen over a long period of time.

So, if you have this chemical, the acute effects and the chronic effects for most of the chemicals, they are already known. When this environmental sampling was done, then if any chemical was found, people can now know what the impacts will be. Let us look at the impacts.

Acute leukemia which is blood cancer, Aplastic anemia which is again another blood disorder, Pancytopenia, Chronic lymphatic leukemia, Lymphomas, Anemia, Neutropenia that is all these different kinds of blood disorders are popping up. Paralysis, Respiratory and cardiac arrest, Visual defects, Deafness, Respiratory distress, Death, Liver tumors.

So, we are observing that all these different kinds of chemicals like benzene, toluene, benzoic

acid, linden, trichloroethylene all of these are now be found in this area and there are certain acute effects like narcosis, irritation or liver damage, allergy, anesthesia; but there are also these chronic effects a lot of which are cancers.

So, we are observing that these chemicals over the long term can result in cancers, they can result in things like blood disorders or they can result in paralysis or they can result in neurological disorders. So, we are observing all different kinds of disorders because of these chemicals. Now, if you are living in an area that is having these chemicals and the government has done a study and found out that these chemicals are actually in that area; what will you do? People started to panic; people started to agitate a lot.

In this case, the health impacts also told that the relative odds ratio for miscarriages among women living on the canal was 1.49 or nearly one and a half times the expected rate within the general population. That is these sorts of health damages, they were not just theoretical; people were actually observing that the rate of miscarriage or abortions in this area was a lot higher than that in the general population.

So, the situation was pretty alarming. The Hooker Chemical Corporation started a propaganda war. They started to say that no, we are not the culprits; we are the people who actually built this area, we are the people who provide jobs to people in this area and so on. But still, they are not telling the people they are not coming out and telling them that ok, so and so wastes are there in this area. It is for the investigators to find out what is inside.

But what the government did was to make a Remediation plan. Now, what was this remediation plan? There was this Love Canal that was all filled up with the chemicals. The remediation plan was to cover it up with a top layer of soil so that water does not seep in. Whenever there is rain and if water seeps in, then the chemicals find it much easier to come out.

One step in remediation was to cover it with a layer of topsoil so that water does not get inside and any water that falls, it should get out of these channels. Then, there were these canals dug so that the residues that were getting into the basement, they got an area to move out. So, these trenches were dug and, in these trenches, the idea was that the chemicals that were seeping into the basements would get into these trenches and they would slowly flow out and there, they would be collected and perhaps treated.

So, this was the remediation plan that was made and also, the waste barrels that people could find out, were removed from this area. This is a barrel. And you can look at the scale of the operation, so many barrels of toxic waste that are there in the canal are now being removed. But people are still panicking. The residents will start to evacuate. This is a family that is picking their belongings to evacuate to safer housing; houses get abandoned.

This new colony that was set up in this area that was having a prime property or a prime location, now it is getting abandoned. The house rates fall like anything and the residents are moving away. The school that was built was demolished .And the remediation work, it involved a lot of earth moving, bringing of holes and removing the chemicals.

But still even today, it is a long-standing problem. Why? Because we still have a large number of base barrels that are still there in the neighbourhood; they are still corroding the area, they are still influencing the surroundings. We still have that smell in the area. Now, the thing to remem-

ber here is that if the Hooker Chemical Corporation had decided to go with the well-set plan that whenever you have a chemical waste, you should not release it into the environment, you should treat it.

If they had followed that principle, then none of this would have occurred. But because this treatment involves an externality. If they dumped these ways and if they came up with an agreement that they are not responsible for any of these, the person who is buying this takes all the responsibility and these kinds of loopholes, permit people to go on polluting and when these chemicals get released, the negative impacts are faced by the whole of the society with very tragic consequences.

This is something that we need to keep in mind, that these kinds of environmental disasters occur because there are certain corporations that are providing jobs to people. This is what Hooker corporation also said in the propaganda war, that if we were not here, you people would not be having jobs. If we were not here, you would not be having this new society in the first place; they would not be prosperous in this area.

But then, when we talk about things like prosperity, when we talk about things like employment, it does not mean that people should be ready to take up employment even at the cost of their health. That is to say if there is a development that is happening in terms of higher incomes or in terms of employment or higher standards of living, then we cannot say that this development will be done without any thought about the costs that are important.

Because in a number of cases, in the short-term people would only look at ok we are getting employment, we are getting a higher job, we are getting a job in this factory. But then, in the long term, the consequences are felt by them, by themselves or by their children. And in a large number of cases, we have observed that whenever there is a corporation that knowingly or unknowingly pollutes the environment, there are human costs also involved.

So, while the corporations are giving prosperity, they are also giving a lot of human costs, they are also giving a number of diseases, they are also giving a large number of deaths and it is as a society that we need to understand and we need to decide what we need. Are you only looking at the short term or are we also serious about what will be the impacts for our children and our grandchildren?

Because whenever anything wrong happens, in this case as well whenever the residents got to know that there are industry chemicals, they started to protest against the government. Why doesn't the government do anything? Why doesn't the government give us compensation? Why doesn't the government evacuate us?

So, in the last resort, people will always go to the government; but then, the corporations also have to be made responsible for their actions. Only then, will the corporations stop doing such kinds of environmental damages. So, this is a very important learning from the issue of Love Canal. Another case is The Delhi Smog. Every year, in the winter months, our natural capital suffers from a very huge amount of pollution that results in smog.

Smog is a term that refers to smoke plus fog; so, this is the smog. So, when we talk about the Delhi smog, it is a situation where we have a huge amount of smoke and foggy conditions because of which that smoke gets attached to the fog particles and that results in a heavy amount of

pollution.

So, here, if you go to Delhi in the winter months, you will find a situation like this. So, there is smoke everywhere and the conditions are fogged. You do not have a very good amount of visibility; you cannot look far out. The media has been calling it things like a Gas Chamber and the government has also been doing something about it like distribution of masks to students so that they do not suffer from the negative health impacts of this smog. But the question is what are the reasons for this smog? This smog is a big environmental disaster.

The environment is not good, the environment sometimes is dangerously toxic. People are suffering from health impacts from running nose, running eyes, allergies, cough, asthma, to even things like heart diseases that are resulting because of this huge amount of pollution. The governments are very concerned about this. But the thing is if you want to stop pollution, you at least need to know what is causing this pollution.

Now, when we talk about the Delhi smog, when we talk about the Delhi winters, it is important to know what are the conditions like; what are the weather conditions like; why do we only get this smog in the winter seasons, why don't we get it in the other seasons? Because if we talk about the sources of pollution things like cars; so cars and other vehicles, they are flying throughout the year.

Why don't we get this condition in the summer season? What is so special about the winters? If we talk about things like thermal power stations, they are working all the time. If you talk about things like construction activities, burning of waste, it is happening at all times. Why do we get smog only in the winter season?

If you look at that weather profile, we will find that the maximum and the minimum temperatures are like this. So, here we are observing from 1st of October to 14th of November and in this period the maximum and the minimum temperatures are going down which means that this is now the beginning of the winter season.

And in this period, the precipitation or rainfall is 0, which means that if there are any pollutants in the air, there is no rain to wash them down. If there was any rain in this period, then probably the amount of pollutants would have gone down because the rain would have brought them down from the air to the ground. But what we are observing is that in these months, there is absolutely no rainfall or even when we get rainfall, it is so small that it does not play a big role.

But the temperatures are down and the relative humidity is very high. In the morning the relative humidity is close to 100 percent. Now, if this relative humidity touched 100 percent, then we would have rainfall. But here the relative humidity is very close to 100 percent; but it is not touching 100 percent.

So, we are not getting rain. But when the relative humidity is close to 100 percent, it would mean that it will be very easy to generate a fog. Now, what is the fog? In the case of a fog, the water that is present in the form of water vapor in the air, gets condensed on the smoke particles or on the dust particles and becomes very small water droplets. Now, these droplets when they are suspended in the air, they behave very much like a cloud and they reduce the visibility. So, that is a fog.

In the morning time, the relative humidity is so high that it generates a very good condition for a

fog. In the afternoon, the relative humidity goes down; but still, it is close to or above 50 percent, which means that the fog will not dissipate very quickly. In these seasons, if the air heated up, then the water droplets that had condensed on the dust particles would again evaporate back.

But then because of the low temperatures, we are not seeing that condition. So, the relative humidity decreases, but it does not decrease sufficiently enough, probably because of the cold conditions. Then, if we look at the wind speed; now wind plays a very important role because if there is wind, then it would probably take the pollutants away from the area.

If there is an industry and this industry is giving out smoke and if there is a wind movement, then what will happen is that this smoke will move to far away areas. So, it gets diluted. But if you look at the wind conditions, we will find that the wind speed is also progressively decreasing.

The wind speed was close to 4 or four and a half kilometers per hour in the beginning of October; but by the middle of November, it is now less than 1 kilometre per hour. So, now there is no wind to take the pollutants away and, in these conditions, we observe a phenomenon that is known as temperature inversion.

Temperature inversion. Now, what does that mean? In normal circumstances, the air near the ground is hotter than the air that is upwards; that is, as we move from the ground level to higher altitudes, the temperature goes on decreasing. Now, that is the normal temperature profile that we observe.

That is, if we look at a vertical profile if this is the ground level. So, here the temperature is high and at a location that is upwards, the temperature is low. Now, this has a very important role in our normal climatic functions because at higher temperatures the air is less dense which means that the hot air tries to move up and when it moves up because in this case, the air above that is denser, the air below is lighter.

This air tries to move up and somewhere this air will try to go down. In normal circumstances, the air is moving from the ground to the upwards locations. But what happens in the case of temperature inversion is that we have a situation that is opposite to that.

In the normal circumstances below is hot above is cold and so, the hot air rises and takes the pollutants away. So, if we have this industry, the smoke is going up. In the case of a temperature inversion what happens is that the above air is hot and the below air is cold. Now, the cold air being denser, it does not rise and so, any pollutants that get released, they get trapped in these lower layers.

Essentially the upper layers of air which are hotter are acting as a lid on the top. Any pollutants that come up in the bottom layer, they will get entrapped here. Now, why do we have such a situation? This is happening because in the normal circumstances, the sun would have been heating up the ground. So, the sunlight is able to pass the air and when it reaches the ground, then it heats up the ground because it gets absorbed by the ground surface.

What happens is that in the normal circumstance, we have the sun and we have this ground layer and the heat of the sun is able to heat up this ground layer. So, this gets heated up. When this ground air is heated up, it means that the air that is surrounding this area is also heated up.

So, now, the temperature of air in this area is high; whereas if you look at a point above, then the sun rays are able to cross or pass through the atmosphere, so it does not heat up the atmosphere

that much. In these upper locations the temperature is low. This is a normal circumstance; the ground gets heated up heating up the air that comes in contact and the air that is on the top is colder and so, this warm air continues to rise.

In the case of temperature inversion, what happens is that in this winter months, the sun is farther from this location and so, this ground is not getting heated up that fast and so, the bottom layer is now not that heated up. The heating is now not happening. Once that happens and because you have a great amount of strong or you have clouds which are preventing the light of the or the heat of the sun to reach to the ground, what happens is that the ground does not get heated up that fast and once the ground gets cooled up and it is not getting heated because of the sun.

Now, we have a situation when the ground layer is colder. So, this area is now colder. Colder means that the surrounding air will also have a lower temperature, but the air that was there on the top is now relatively warmer. So, what is happening is that the air on the top is not getting heated up in the case of a temperature inversion.

What is happening is that the ground is not getting heated up which means that the ground is getting very cold and due to that the air that is surrounding the ground is also getting cooler. Now, in such a circumstance, we have a condition where any pollutants that are released, will get trapped here.

And if you look at the level of pollutants in Delhi in this period, this is what we see. So, on the right we have the air quality index. So, we move from good to satisfactory, to moderately polluted, to poor, to very poor, to severe and this is the air quality index some indices for these different factors of pollutants.

PM10 is particulate matter that is of a larger size. PM2.5 is particulate matter that is less than 2.5 microns and we have nitrogen dioxide and carbon monoxide. And if we look at the PM10 level, we will find that the PM10 level is this line and it is now getting very close to very high values which is entering into the severe conditions.

If you look at PM2.5 that is even larger and in certain portions of the month that is after say 7th of November, it has already reached a level that is having severe health consequences. Now, the question is why do we have these conditions; why do we see this peak; why do we see this peak? What is causing this pollution?

To understand that, we can look at different pollutants in a differential manner. Now, why is that important? This is important because different pollutants have different sources. If nitrogen oxides are going up in the air, it means that the vehicles are the primary cause of pollution. Why? Because nitrogen dioxide, nitrogen oxides get released during the process of internal combustion that is happening in the vehicles; whereas, if the sulfur dioxide levels go up, it means that the majority of pollution is happening because of the role of thermal power plants which are burning coal. Because coal has sulfur inside and so when coal is burnt, it also releases sulphur.

If you look at a vehicular exhaust, it has a very minimal amount of sulfur and so, by looking at nitrogen oxides versus sulfur oxides, we can make a correlation whether vehicles are more important in this pollution or whether the stationary sources like thermal power plants, are more important. Now we will look at each and every pollutant in a differential manner.

The first pollutant that we are observing is ammonia. Now, this curve is showing the amount of

ammonia or the concentration of ammonia with reference to the percentage of October beginning. So, if in the beginning of October, we assume that the percentage is 100 percent, how does it shift throughout these months of October and November. It moves from close to 100 percent and it is roughly stable till around 20 October; but after that, it starts to increase and then, it reaches to a maximum at around say 7th or 8th of November.

What releases ammonia? If you look at the sources of ammonia, we will find that the major sources enable manure followed by mineral fertilizers; especially, the nitrogenous fertilizers, followed by this one 13 is biomass burning, followed by things like crops and their decomposition, human waste, soils under natural vegetation.

The common thing that you will notice here is that ammonia is released from biological sources like animal manure, burning of crops, burning of residues, human waste. So, all of these are organic substances. And if you look at animal manure, now there will hardly be a change in the amount of animal manure that is being generated in different months because it is not that in the months of October and November.

We get animals from different areas that come to Delhi and so, the amount of animal manure goes up. That is not the situation. Similarly, if we look at mineral fertilizers. So, yes, some amount of fertilizers are added; but then if we look at this time, this is the the time around Diwali and around Diwali, there are no new crops that are being sown. So, fertilizer application can also not be a reason. Why? This ammonia is being generated in a large amount.

Soils under natural vegetation or human based, or crops and their decomposition, are again not very important sources. They are important sources, but they are not that important because there will not be a major change in these factors in the months of October and November as compared to in the other seasons.

Now, of course, because we are having a condition of temperature inversion, so any ammonia that is released into the air that gets trapped and so, it will play a role in increasing the concentrations. But then, one important factor here is biomass burning, which is shown here in pink and where do we get biomass burning?

Well, this is a satellite image that is telling us where we were observing signs of burning or fire signatures on 15 of October. Now, here we can observe that in major parts of Punjab, Haryana and Western Uttar Pradesh, we are seeing a very large fire signature. Now, this is because in those areas people, once they have harvested the crops, and most of the harvesting has been done through machines these days, so, whatever stubble remains, that is burnt in preparation for the next agricultural season. Now, the question is why would somebody burn these stubbles? In earlier days, what people used to do is that they would bring the animals onto the field; animals especially goats, goats and sheep they used to be brought into the fields and they used to eat up all the stubble and the manure that they used to release that, also used to act as a fertilizer for the next crop.

But that was being done when the fertilizers were or the chemical fertilizers were not available or they were very expensive. These days because of advances in technology, advances in industrial production, we have reduced the cost of fertilizers, especially things like urea and so, now, it is much more cost efficient to just purchase the fertilizers and put them into the field.

Now the goats and the sheeps are not used to that large an extent. At the same time, when in the early days people used to harvest their crops, they used to do it with sickles and when the crops are cut using sickle, the amount of stubble that is generated is very small; but with harvesters, the amount of stubble is also very large.

In a field that has a very small size of stubble, something like this, it is difficult to burn the speed because the fire will not spread from point A to point B. But what is happening now is that with the harvesters the size of the stubble is very large and so, if the farmer puts this portion on fire, the fire is very easily able to reach the other areas of the field.

And so, now, it is much cheaper, much more effective to just burn the field and this is what we are observing in these satellite fire signatures. In these areas of Punjab, Haryana, in Western UP, we see a major fire signature that has not been seen in the other areas. Primarily, because in the other areas, our agriculture is not that mechanized; people are not using harvesters to that large in extent and so, it is much cheaper to just cut these stubble and use them as heat in the other areas and this fire signature continues.

This is 15th of October, this is 25th of October here again Punjab, Haryana and Western Uttar Pradesh, you see a major fire in these areas. In other areas as well, we are now starting to see the fire signatures as more and more agriculture is getting mechanized. But even today, primarily, it is Punjab and Haryana in Western Uttar Pradesh, where this crop field burning is happening.

This is 4th of November, again Punjab and Haryana are burning; this is 10 of November. Now, in all this period, the majority of the wind is coming from the North-Western direction, which means that if Punjab and Haryana are burning and we are getting winds in this direction, it shows that all of this smoke can reach our capital of Delhi.

So, we have observed two things; one is that the ammonia level is going up which is telling us that there could be biomass burning. We are observing biomass burning in the satellite imagery and the one conditions are such and especially in the beginning of October, that they are able to bring this smoke to Delhi.

Now, the wind direction is from the North-West to the South-East, but the wind speed is very low, which means that the wind will bring this pollutant or all this smoke; but it is not a fast enough wind to carry this away to larger areas. It is now getting accumulated and because of temperature inversion, there is also no chance of this pollutant getting higher up into the atmosphere and getting lost and so, it gets on accumulating in the air. So, this is one reason.

Let us now look at another pollutant; nitrogen dioxide. Now, this is again the percentage of October beginning. So, it goes on increasing. Now, if we look at sources of nitrogen dioxide, we will find that the majority is the mobile sources and these mobile sources are the vehicles.

What happens in the case of petrol or diesel vehicles is that we have internal combustion engines in which petrol and diesel are burnt at very high temperatures. Why do they play a role? Well, our air is more than 70 percent nitrogen and at very high temperatures that are there inside these internal combustion engines, this nitrogen can react with oxygen and give out nitrogen oxides.

That higher temperature is not there in most of the other fire sources and so, our kitchen fires or normal fires will not generate that much amount of nitrogen oxides as will be generated by these internal combustion engines and so, the mobile sources are the largest sources of nitrogen oxides.

In this period from October to November, it is not that the number of vehicles are going up every year; it is not that we are bringing vehicles from other areas into Delhi so that we can have more of nitrogen oxides. But what is happening is that because of the temperature inversion, any amount of nitrogen oxides that are given out by these vehicles, they will remain trapped in the Delhi air and so even though the numbers are not increasing, but because the nitrogen oxides are not getting out. So, the concentration increases. So, vehicles also play a role.

Next, let us have a look at sulphur dioxide. Now, here again sulphur dioxide goes on increasing. We see a very sharp increase around the 21st of October and after that, it goes down, but then it remains high. If you look at the sources of sulphur dioxide, the largest sources are electricity generation and industry and if you look at the mobile sources, they are very small sources.

This is because when coal is burnt for electricity generation in thermal power plants, the sulphur that is there present in the coal, that also gets burnt and becomes sulfur dioxide. Also, in a number of chemical reactions that occur in industrial processes sulfur dioxide is released.

But then, the amount of sulfur that we have in petrol or diesel is already very low and so, vehicles do not form a major chunk of the release of sulphur dioxide in the atmosphere. So, these are the major sources. Now, what we are observing with this is that the electricity generation or the industries in Delhi and surrounding areas are also playing a role in the Delhi smog. But then, how do we explain this huge rise around the 20th?

Well, this is because we had the festival of Diwali here. During the festival of Diwali, people burn crackers, people burn fireworks and sulfur is a very important component of the explosives that are used in these crackers. When these crackers are burnt sulphur oxides get released and this is one explanation that can tell us why during this period, we saw this heavy rise in the concentration of sulfur dioxide and once this concentration has increased, then it remains high for the rest of the period, which means that the cracker burden is also playing a role.

So, different components are playing a role. We saw the role of biomass burning, we saw the role of automobiles, we saw the role of industries, we saw the role of the crackers. If you look at other substances like carbon monoxide. So, the concentration increases, it roughly doubles from the beginning of October.

Now, here again, it is not that more and more of incomplete combustion is happening in this period. But what is actually happening is that because of temperature inversion, the carbon monoxide that has been generated is not able to move out. But this is also telling us that a lot of incomplete combustion is happening and quite a lot of incomplete combustion also happens when the municipal wastes are burned.

If there is a fall of leaves and if people just burn that, then that would also release a lot of these chemicals that would release ammonia, that will release carbon monoxide. And when we look at all of these chemicals together, then we also have a lot of reactions that are happening that is when we have ammonia that is high and when we have sulphur dioxide that is high, we can have the formation of ammonium sulphate in the atmosphere or in the air.

Now, this ammonium sulphate will be in the form of a particle and this is what we are observing here, that the concentration of PM10 and PM2.5 is going up. This is because of a large number of photo reactions that happen when you have these huge concentrations of pollutants in the air.

So, because of these chemicals, these chemical reactions, we have the formation of a large number of particles.

Many of these particles are also getting released into the atmosphere because of things like construction activities. So, whenever there is a construction activity, there will be a lot of dust that gets released; a lot of dust also comes up in the form of the smoked particles in the vehicles or whenever uh the waste is burnt or a lot of it is also coming from the agricultural waste that people in Punjab and Haryana are burning and the wind is bringing them on today.

So, what we are observing is that there is not one source of the pollution in Delhi or the smog in Delhi, there are a large number of sources and these sources include primarily the changed weather conditions. Because of temperature inversion, the pollutants get trapped; they have nowhere else to go and so, if people were more sensitive, they would try to stop any release of pollutants whatsoever in these months because in these months, if any pollutant is released, it will not go anywhere away.

If you just remain there indeed. So, if you want to bring these pollutants down, you will have to act on all of these sources. We cannot just say that yes vehicles are the culprit, so vehicles should be banned or that only the agricultural waste burning is a culprit, so that should be banned or that industries are a culprit and industries should be banned.

No, this is a cumulative effect of all of these different sources that are acting together and so, everything needs to be done in moderation. All sources of pollution have to be brought down because the weather conditions are such that the pollutants will not go away. But then, a large fraction is also being generated by the agricultural waste, the thermal power plants in industries and the automobiles. So, they will also have to be toned down.

To sum up, there are certain environmental disasters that are easy to explain because they are the result of the greed or the procrastination of a few actors such as the Love Canal tragedy. If the Hooker Chemical Corporation had treated the waste before dumping, this disaster would not have happened.

If the Hooker waste corporation had decided that before giving up this land to the Education Board or for the construction of buildings nearby, they would have treated the waste; then, this disaster would not have happened. If the people who bought this land, the Board of Education, had looked into the agreement that they were signing and had taken action, this disaster would not have happened.

But in this case the consequences were faced by so many people who lost their homes, who had to suffer from bad health. Now, in certain other environmental disasters such as the Delhi smog, there are routes of a large number of factors from weather to things like agricultural waste burning, to vehicles, to electricity generation, industries and so on.

In such disasters that are a result of a large number of players that are all contributing to the disaster, it becomes more of a social responsibility together with an individual responsibility to curtail these sources of pollution. Because after all, whenever we release these pollutants into the air, it is we ourselves, and our children and our grandchildren that will have to suffer the consequences and so, it is in our own interest to become more environmentally friendly, environmentally conscious.

That is all for today. Thank you for your attention. Jai Hind!

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