Introduction to Sustainability

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To whom so ever it may concern

I, Abhishek Sahu, 11915545, hereby declare that the work done by me on "**Introduction to sustainability**" from 05/20 to 11/20, is a record of original work for the partial fulfillment of the requirements for the award of the degree, B.Tech.(CSE)

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CHAPTER 1

INTRODUCTION

Introduction

Environment, in present world it seems like a normal topic and most of the times ignored. However, this is the most important topic one should think. Let's consider, an average person in his life always thinks about his family and his upcoming generation. He wants to make the life comfortable for them. So, he earns money not only for himself or his present but securing his future generations too. Basically, this thought, and care is limited to money most of the times. there is a negligible number of people who give it a thought and try their best to save resources, environment and use it wisely. Sometimes, we see them and most of the people don't help them instead of that they make fun of them. This shows us where we are headed and what we are going to leave for our descendants. They say one person can't make a change, but one person can start the chain, and this will help us to do the preserving of resources and use them wisely. This does arise a question about how to do that, had anyone in the past given it a thought or is it just a new theory? Well, the term who compromises these things is known as 'Sustainability'. So, what is sustainability?

Sustainability

Sustainability or widely known as 'sustainable development' can be referred as "development that meets the needs of present without compromising the ability of future generation to meet their own needs". Other nations consider many aspects in this but all of them share some common traits "the essential needs of world's poor and the idea of limitations imposed by state of technology and social organization on the environment's ability to meet present and future needs."

Thus, there are three areas that sustainability covers: economic, environmental, and social. Economic interests define the ideas, frameworks, strategies, and the flow of financial capital that are relevant to economic field. Environmental aspects share the diversity and their interdependence in living systems and the impact of human waste. Social area consists of interaction between institutions, firms and individuals, functions expressing human ethics and values and decision making that affects a collective. Figure 1.1 shows how this paradigm works and illustrates the importance of each field in others.

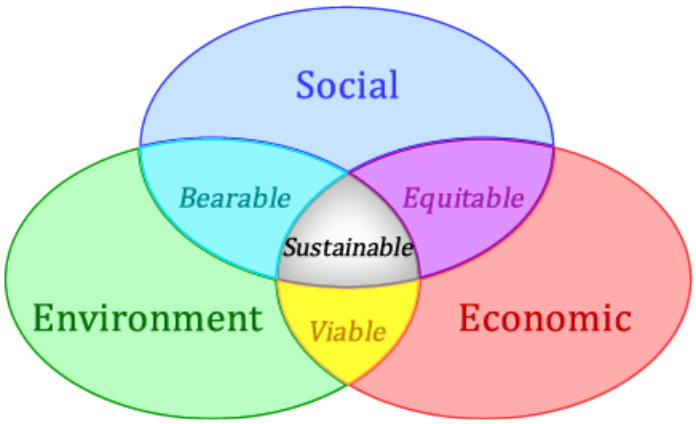


Figure 1.1: Overlapping themes of sustainability paradigm

The IPAT Equation

$$I = P * A * T$$

IPAT expresses a balance among interacting factors. I represent the impact of any given course on environment, P stands for human population, A stands for level of consumption per person and T is impact per unit of consumption. The equation is not meant to be mathematically rigorous, rather it provides a way of organizing the information.

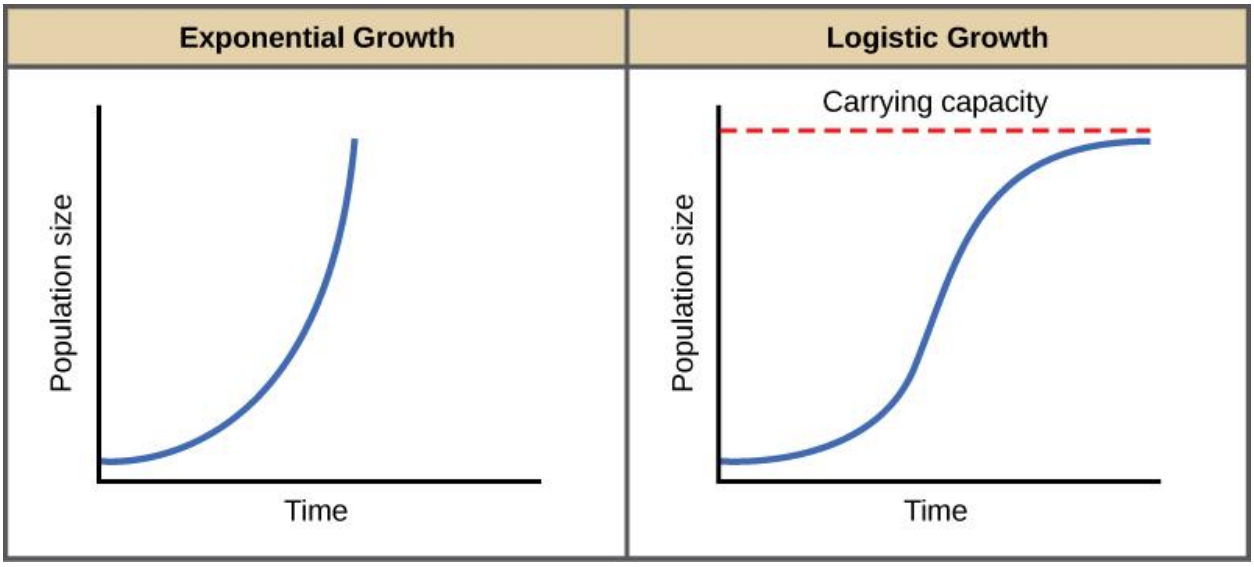
So, what does this formula mean? This equation simply implies that the impact is directly proportional to the world's population which means if the population increases than the impact on environment will surely increase, same stands for consumption and impact per unit consumption. However, there is a problem with IPAT, this shows that every term is independent of each other but if we increase population than the consumption will surely increase, and the impact will have an exponential growth. So, it we try to look into future with the help of this equation than we can not determine impact on the environment.

Growth Curves

In simple words, growth curve can be defined as the timeline that shows the growth or decline in a nation's population. Growth curve can show three things if there is decline in population with respect to time, growth in population with respect to time or the population is somewhat stable in time. Let us see about the different type of growth curves:

J-shape Curve:

As mentioned in name the graph is somewhat in shape of alphabet 'J'. in this type of curve, we see that according to the environment an organism grows and populates the environment with an exponential growth and then stops abruptly because of shortage of resources to live in the environment. These factors can be anything like food shortage, environmental or climate change, toxicity, or human activities. Figure 1.2(a) shows a fine curve which can be considered as J-curve.



(a) (b)

Figure 1.2: Growth curves[(a) J-curves (b) S-curves]

S-shape Curve:

In S-shaped curve it somewhat depends on the density of the population. It first grows slowly then in the middle gets a growth like J-shaped curve (exponentially) and then declines or stops at a time on zero growth at all. S- shape curves are the curves which matches the system environment. Figure 1.2(b) shows the graph for S-shaped curve.

So, as we saw S-shaped curve can be considered sustainable where J-shaped curve is unsustainable. The problem for finding our curve is that at a particular time span those two curves look same and grows exponentially. However, they both when cross the carrying capacity behave differently and this we don't know if we have passed out carrying capacity or not. Some might say that we have passed our carrying capacity in the past and now we are headed to crash according to

the J-curve. But now the only thing that can be confirm that we can now establish our growth according to these curves and plan accordingly.

Malthusian Theory

Global population is approximate 7 billion in present and this did not just grow linearly from the start. According to latest data population growth is somewhat 1 percent right now and if this remained same then in the next seventy years, we could say that our population will be 14 billion. What would happen if we faced this crisis? Well, according to Thomas Malthus, this kind of growth is not sustainable, and he stated this in 1798. According to him population grows exponentially and at a given period it will be double of present time, however the food production increases in arithmetic manner or somewhat linear manner. Figure 1.3 shows this in a graph manner.

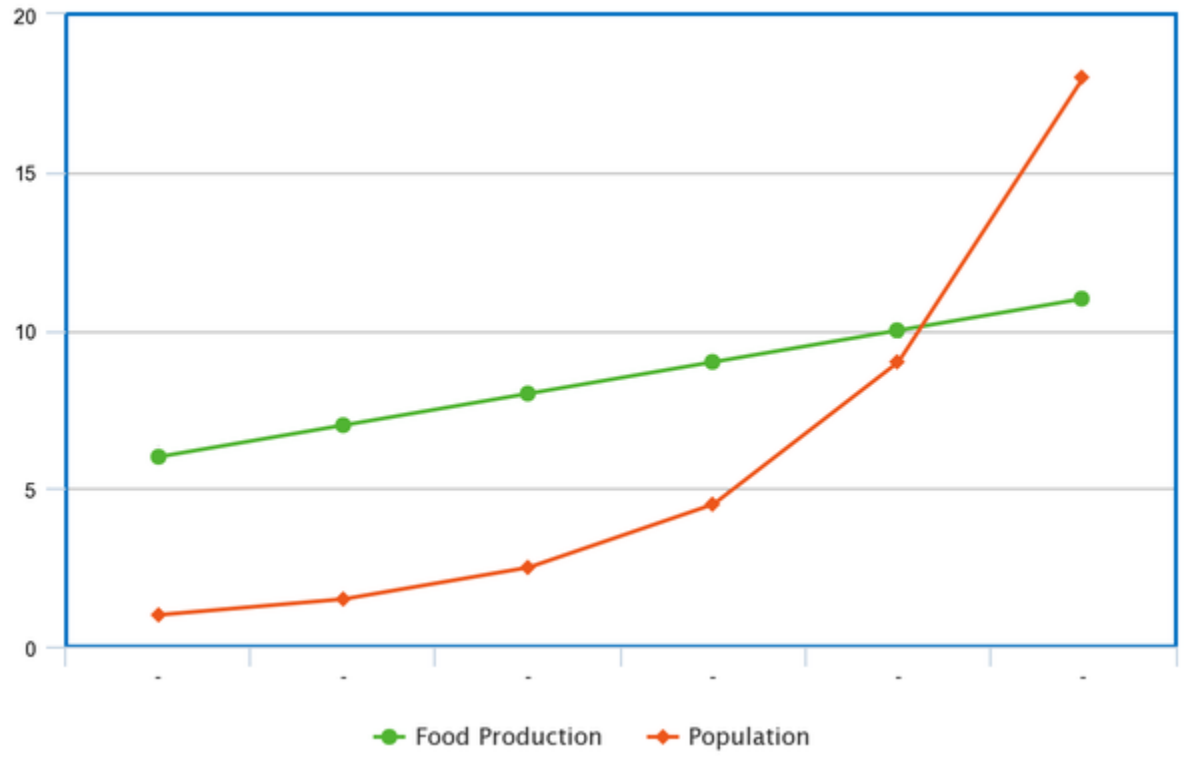


Figure 1.3: Malthusian theory of population growth

According to these lines, the population grows in exponential manner where the food production in linear manner and after a certain amount of time they intersect. What does this intersection imply? According to Malthus this intersection is known as point of crisis and before this point of crisis we can see the food production is greater than population and filling the needs of every person however after the point of crisis the population is still growing while the food production is now less and cannot fulfill every need. This will cause living standards to decrease and a point it will cause starvation. Some people can say that in near future we can develop technology so that food production can increase also, but if we look it in this way then we are just postponing the point of crisis like if we just double the food production than the point of crisis is 70 years ahead now. So, does that mean we are eventually going to face starvation. The population is going to collapse. Mostly all the agriculture runs on fossil fuels which will eventually run out of carrying capacity and does this mean that we are going to face J-curve in near future?

Malthusian theory is about future but when he made this prediction, it made sense but after making this prediction the living standards and population did not faced this crisis rather we are now more wealthier than ever and we have not faced the point of crisis and it's been 200 years since he stated this. So, rising population does not make people poor or caused starvation. Besides that, increase in population also increased world income of men. So, Malthusian theory is interesting but not promising, we have somewhat managed the world by the time of population increase.

CHAPTER 2

POPULATION

Population

One of the many reasons which are making sustainability an imaginary concept is there are so many of us. You can look around and will find yourself in crowd at some point of the day. But does this mean that this increase in population is gradual in every age group? According to some nations there are less college age people now then there ever was. Let us have a look at these variations.

Well, large population does not always imply that we are going to face more population growth in that area in near future. The other factor is the age group which is in majority in the country. Let's discuss this, Yemen is a country where there is a vast group of women which are below 18 whereas if we look at the data of Greece the average of women is 42. This clearly shows that Yemen is the country which is going to see high population cause of the fertility age is more relevant in Yemen than Greece.

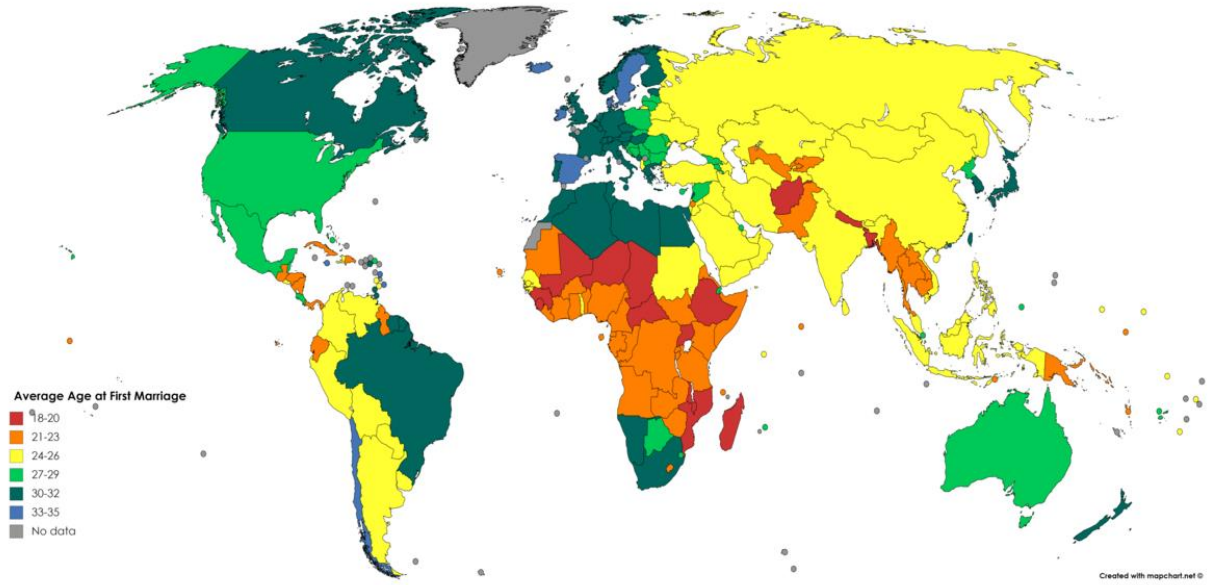


Figure 2.1: Average age of different countries in world.

Let’s have a look at the world map in Figure 2.1, As you can clearly see countries like Canada, USA, Australia and some countries of Europe has an average age of 27 to 35 which shows that they are not going to face population crisis in future as much as the countries like in Africa, Pakistan etc. which have the age less than 20. This also implies that the lower age group countries will have more children per person than the countries in green section.

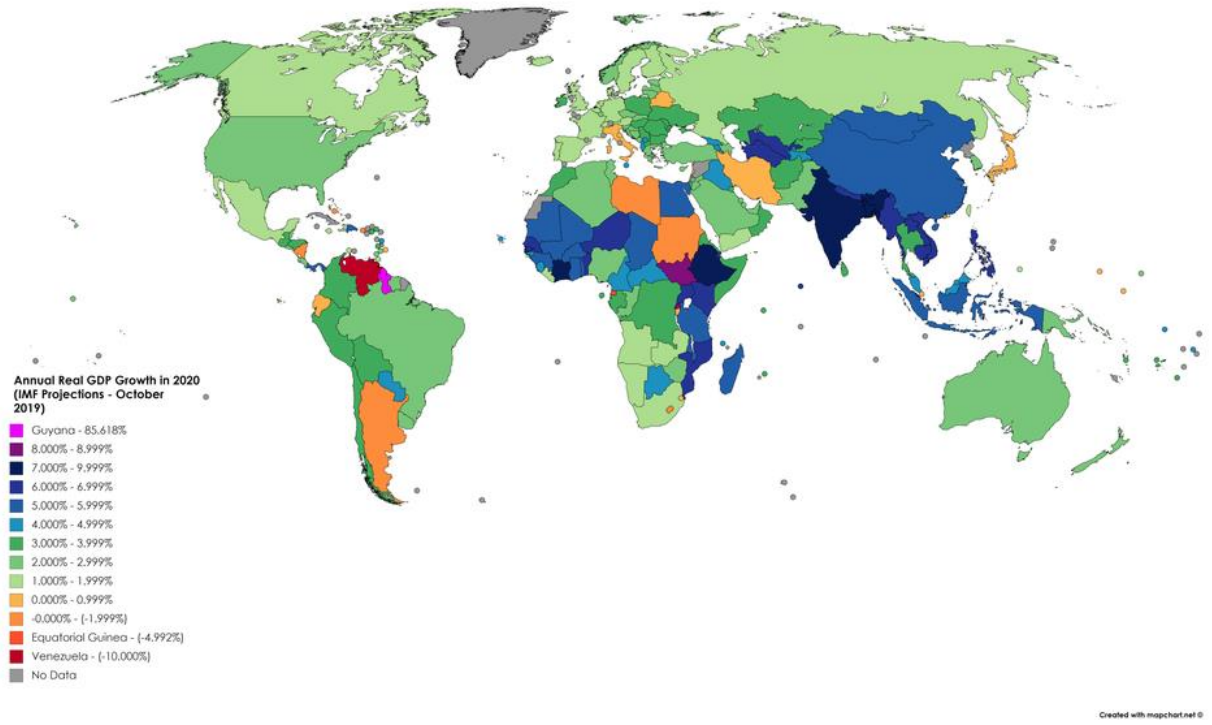


Figure 2.2: Growth rates of different countries.

Now, have a look at Figure 2.2 which shows growth rates of different countries and the blue or purple colored nations are the ones which are showing a significant amount of growth in present where the green ones are at a stable level, if you look closely you can see that there are few countries which are having growth rates in negative. So, there are many plan nations are applying where some are doing that to decrease their growth rates where countries like Singapore trying these plans to increase their growth rates. There is one theory that the wealthier the state the growth rate will be decreased. Is that true? Well in some cases like USA, Britain it is true but there are some inconsistencies like Saudi Arabia where the GDP is good still the growth rate is high. So, it is not always true but yes it can be considered. The other parameter we can think of the education level for women. Have a look at Figure 2.3, You can see the more the human development index

is the less children per woman is there. Countries like central Africa, Nigeria have less human development index and an average of 5-6 children per woman however countries like UK and New Zealand have great human development index and 1-2 children per woman.

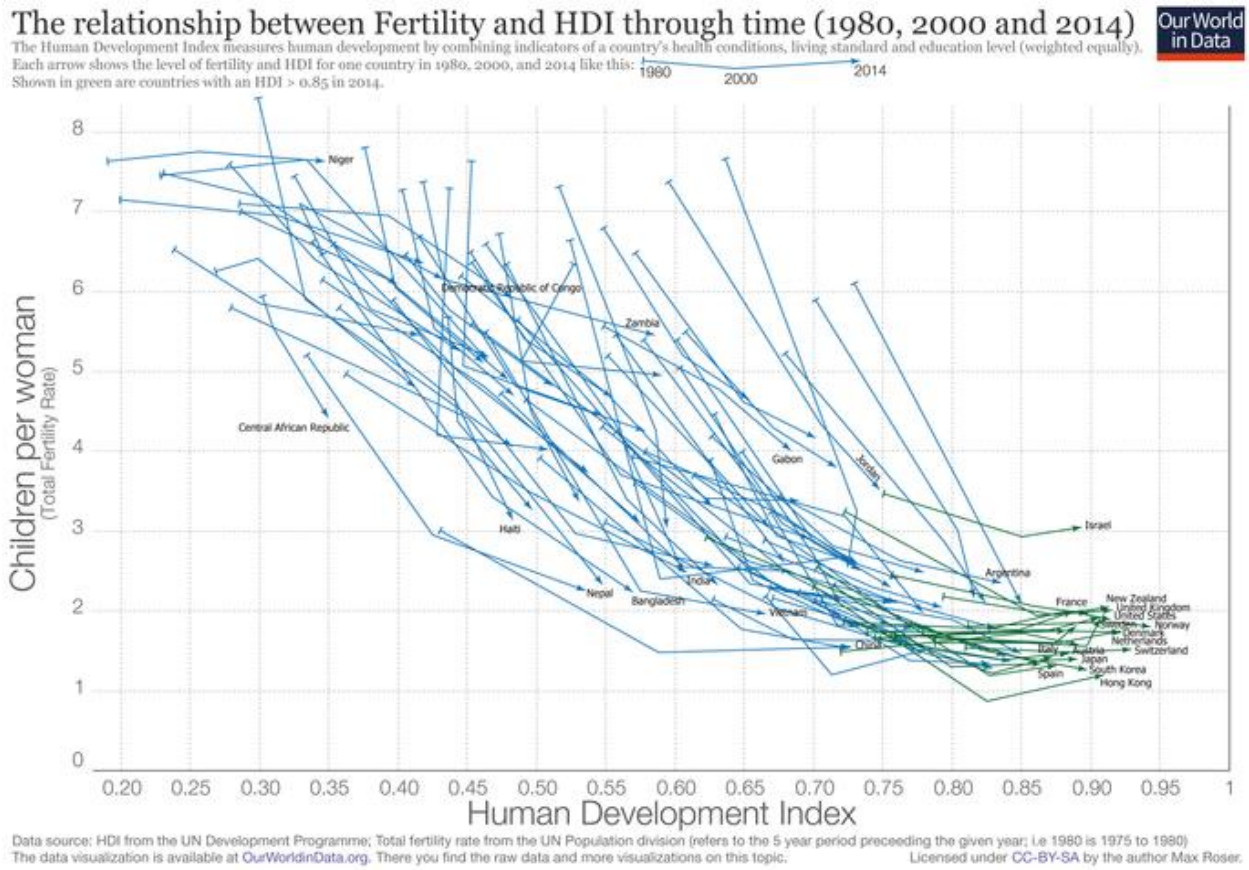


Figure 2.3: Human development Index vs. children per woman

Demographic Transitions

If we look at past century's statistics and the present scenarios the population of India has increased enormously, and the average life expectancy has also increased from 30 to approx. 70. But this not the same case for other countries. There are some countries who are facing the opposite case. Why is this different in different countries? One way to find out is demographic transition. Population number changes when there is a difference in birth and death rates of a country. We can consider Figure 2.4 for this.

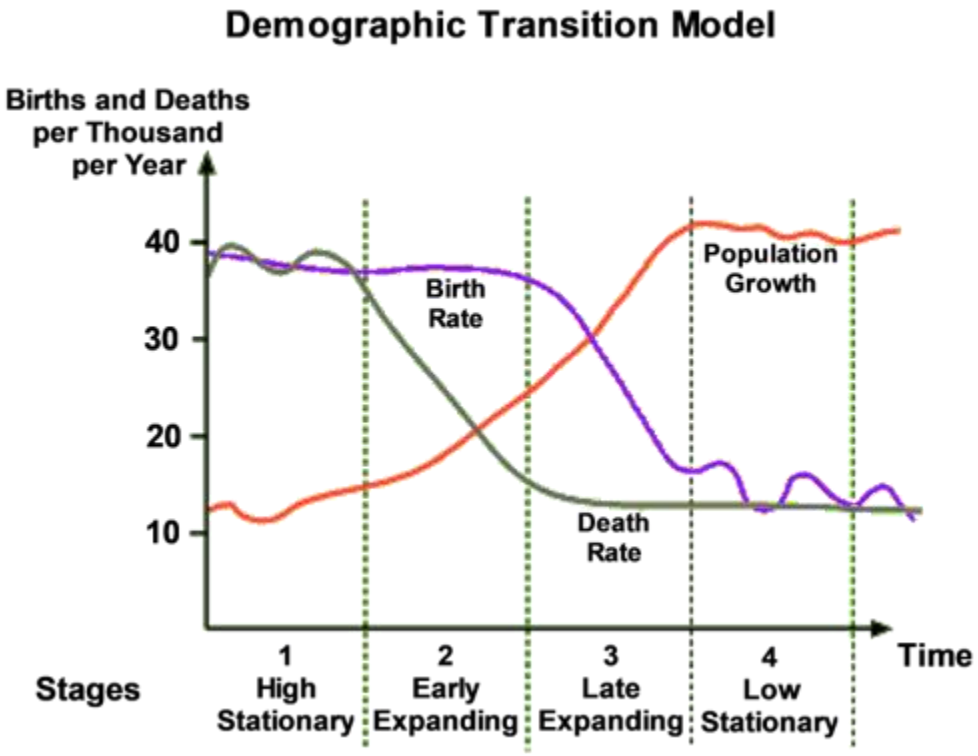


Figure 2.4: Demographic transition

As you can see in early stage when the birth and death rates were normal and difference between them was somewhat constant, the population growth was low, after that when the living standards changed and the people became wealthier, there was a decline in death rates and the birth rates were still stable then there was an increase in population growth and this growth continues when there was a decline in birth rates and after a certain period of time when it again became constant then the population growth is stable. However, the population is now more than ever before. This is known as demographic transition which have four stages: High Stationary, Early Expanding, Late Expanding, Low Stationary. So, how we can identify that which country is at which state right now and what this tells about the future of population in that country?

Pyramid Model

So far, we have seen that the age group does leave an effect on population growth like Yemen and Greece. How are we going to identify this? There is a model called pyramid model which can be

helpful for this. Where x axis shows no of people in million and y axis shows different age groups. So, how are we going to understand future population with these pyramids?

Very Youthful

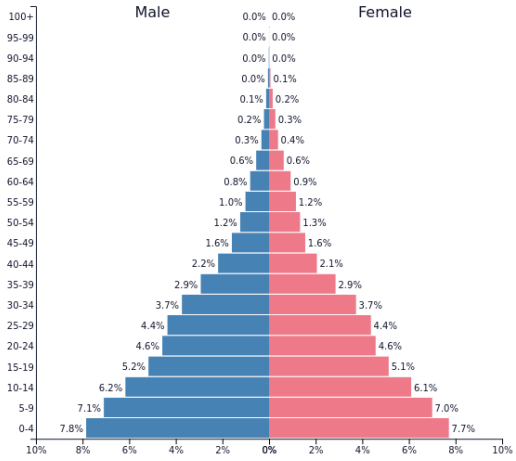


Figure 2.5: Very youthful pyramid model

So, this is the first type of pyramid model, not exactly like a pyramid because it is flat from the surface, this shows that the nation is at a well growth in population because there is a large group of people from youth age group which have potential to populate the nation.

Transitional

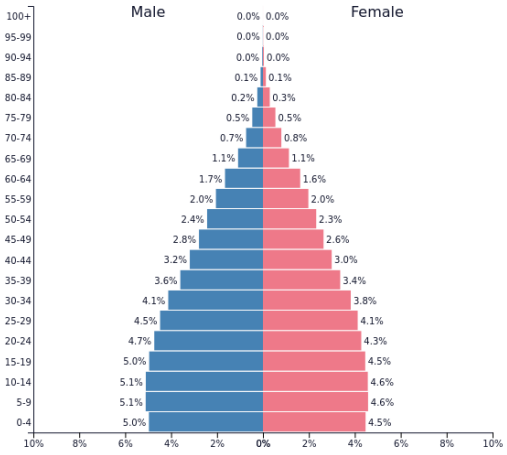


Figure 2.6: Transitional pyramid model

Figure 2.6 shows a different type of pyramid which is not only flat from surface, but also in 20 to 30 age groups and this type of model is going from a transition and will turn into a mature model in upcoming decades.

Mature

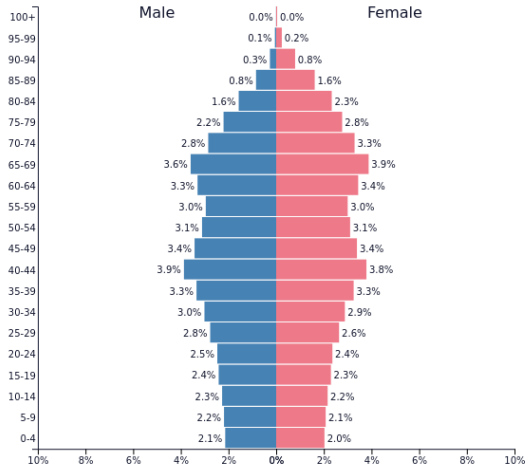


Figure 2.7: Mature pyramid model

This type of model is more of a mature type where the large age group is from 35 to 65 and this type of model going to face a decline in growth rate when these people eventually die.

So, where does this leave us? Just look at Figure 2.8 which shows world population history and estimation for future population scenario.

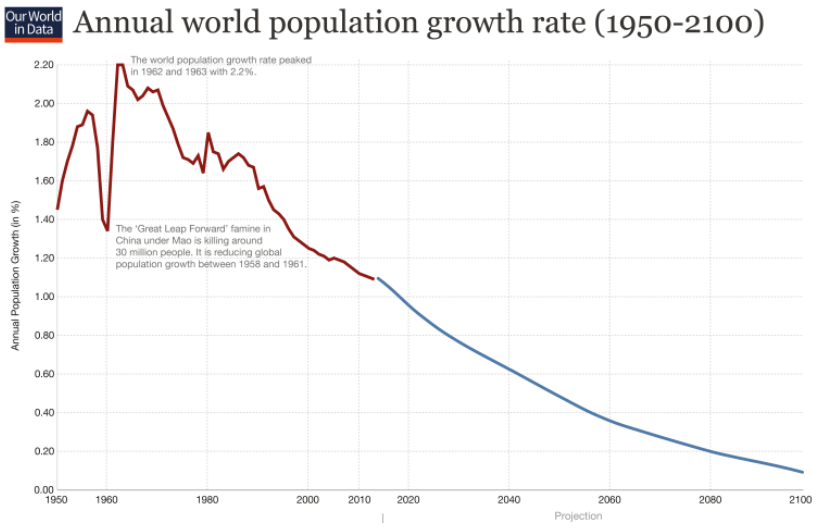


Figure 2.8: Future growth rates

If we see this graph, it clearly shows that we are not going to get a sharp decline like J-shapes curve rather than we are getting a gradual decline in growth rates which is kind of healthy.

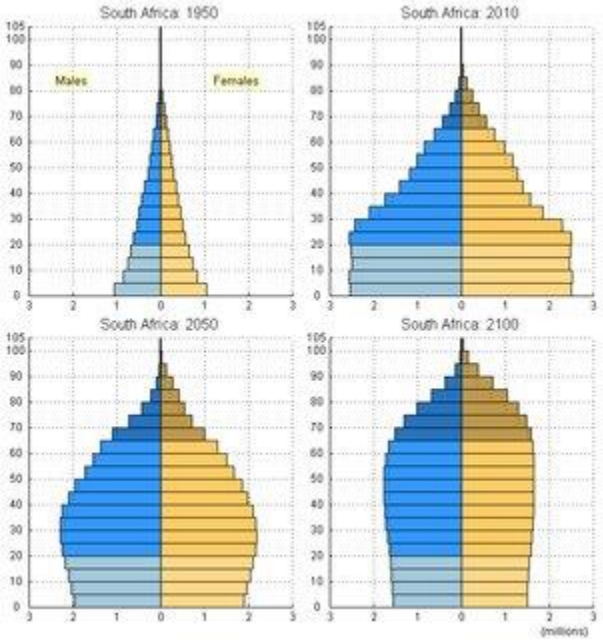


Figure 2.9: World population model

This is the world pyramid model and this shows that as the time passes we are getting a flat pyramid because growth rate is going to decrease and we are going to get a more stable pyramid or a block like structure and this is possible if we get the living standards of developing countries same as the developed countries.

CHAPTER 3

ECOSYSTEM
&
CLIMATE CHANGE

In the Last Chapter we've seen how population growth was fluctuating during the years and how it is going to affect in the future. Now we've arrived at the situation where we are going to talk about how this affects our environment.

Tragedy of the commons

We know that earth has lot of resources that provides us a standard of living and we've also seen how we are utilizing them in a very degrading manner and how it's not sustainable. These resources are like air, water, oceans, soil, and fossil fuel etc. There are many names we give to these misuses one of them is 'Tragedy of the Commons'. Tragedy here means an inevitable destruction where common means the resources we use in our daily life. What if we overgraze the commons? Like, if we use soil too much. This would remove the top layer of the soil which is fertile. But how does it occur? Think it this way, we all have a right to get our daily needs and resources for them, but we are not all equal. Some of us have more resources than we need, and others try to equal them and in pursuit of that they just add more burden on resources which causes the overutilization and eventually to destruction. So, what are the examples of tragedy of commons? We can consider greenhouse warming, destruction of resources and pollution as tragedy of the commons. So, does this mean that we are doomed and there is no way to fight with this issue? Let's look at the solutions.

Solutions

1. One way to deal with tragedy of commons is personal action means what an individual can do. This one is the easiest way if one is willing to but there is a less chance that this will make an effect because every single person does not possess similar type of thinking.
2. Second way is internal governance or what group of people can do when they act together. This might work. Because of a group pressure sometime individual agree to follow the rules but still it has a chance of conflict and disagreement.
3. Third way is an external force. This can be considered as governmental intervention. This is the way which give individual a very short area of choices and they have to obey these rules either they are doing it willingly or unwillingly.

So, it is solvable, but all these solutions require individual communication and willingness so that this all works fine. Tragedy of commons is an arguable problem. Another arguable problem is world's ecosystem and the fate of the creatures depending on that ecosystem.

Ecosystem and Its Extinction

Biggest threat to earth is to its ecosystem and its extinction by human activities. However large number of extinctions happened in the past does not relate with people. these incidents include big volcano explosion, asteroid collision etc. because of these activities 30 percent of the geni was wiped out. Are we seeing the same decay from human activities? These changes by humans are happening from tens of thousands of years. They had fire, stone weapons as their tools and the most important reason of extinction was migration. History shows the proof that when they migrated from one place to another, it most of the times led to extinction of a particular species. This does shows that not only in present, but we are doing these activities for centuries to for our living standards and destroying earth resources which is causing it to die slowly and slowly. Let's look at these activities and their effect on our atmosphere or climate.

Climate vs. weather

Climate and weather are not the same thing. Weather in one hand shows short term conditions of the atmosphere where climate on the other hand is the average daily weather for an extended period for a certain location.

Climate changes in past

There were changes in climate in the past, it was not always fixed and these changes were not caused by human species but these does help us to understand what should be avoided in order to fight with climate changes. To know about the previous climate conditions, we have to collect data and there are two ways to do this. First way is instrumental way, in this way we use our instruments which were designed by human to estimate the climate changes and try to study the changes in the past. The second way is known as proxy method. This is the process where we collect information from natural process and then we convert this into climate changes information. Instrumental data is pretty straight forward, we make a measurement,

and we know what it means. On the other hand, proxy data is kind of hard to interpret, we must make assumptions and then understand the natural world. One very important way for proxy data is from ice cores. But how does ice help us to understand the climate change? Water is made up of two hydrogen atoms and one oxygen atom. But all oxygen atoms are not alike, we have isotopes. We have oxygen-16 and oxygen-18 which bond with hydrogen and make light and heavy water respectively. Suppose if the weather is warmer at a particular time and the water vaporizes because of it. The light water vaporizes first cause it's lighter. So, this leaves us with if the weather is cooler than we will find more light water molecules in the ice and if it is warmer than there are chances that we will find majority of heavy water molecules. So, if the weather is warmer, light water will form a cloud and we will get snow as light water and a light water layer over the heavy water and if it's cooler than there is chances to get the layer of heavy water over light water.

Modern Climate changes

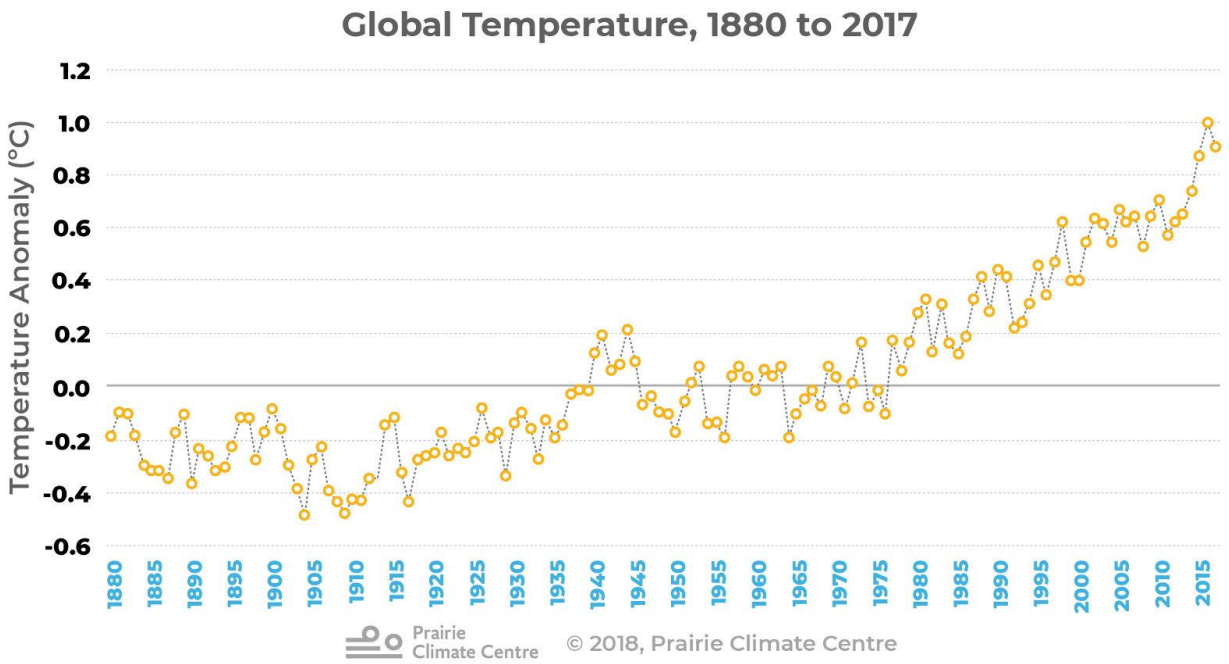


Figure 3.1: Temperature anomalies in past and present

As figure 3.1 shows about the temperature changes, we have come so far from past and it shows how the annual temperature is constantly increasing and because of this how the climate is affected. From 1880 to 2015 we increased global temperature by -0.4 to 1.0 degree Celsius.

What were the effects of this huge change in temperature? We have lost most of our glaciers and now the sea level is also increased and because of this and green house effect we are loosing our ozone layer and the other hand we are using fossil fuels which is not only on verge of extinction but creates a huge amount of pollution which affects us in many ways. So, this is how it's going to happen? Is there not any way to stop this unannounced epidemic? For one task we have to handle our energy consumption. Let's do something about it.

CHAPTER 4

ENERGY

Energy

Energy is very important. We live on energy. Most of our energy comes from fossil fuels but there are two serios issues with fossil fuels: they are limited, and they cause climate change. We are using fossil fuels so much that in only 50 to 100 years of time we are going to be the reason of extinction of these resources. We have renewable energy resources also but there is many inconsistencies with those, they are not efficient, they are not able to fulfill human energy needs and they are expansive to build.

We can try to use renewable resources but the main reason we are not doing it in present is our energy needs, if we look closer into it then Figure 4.1 shows us the perfect illustration for us.

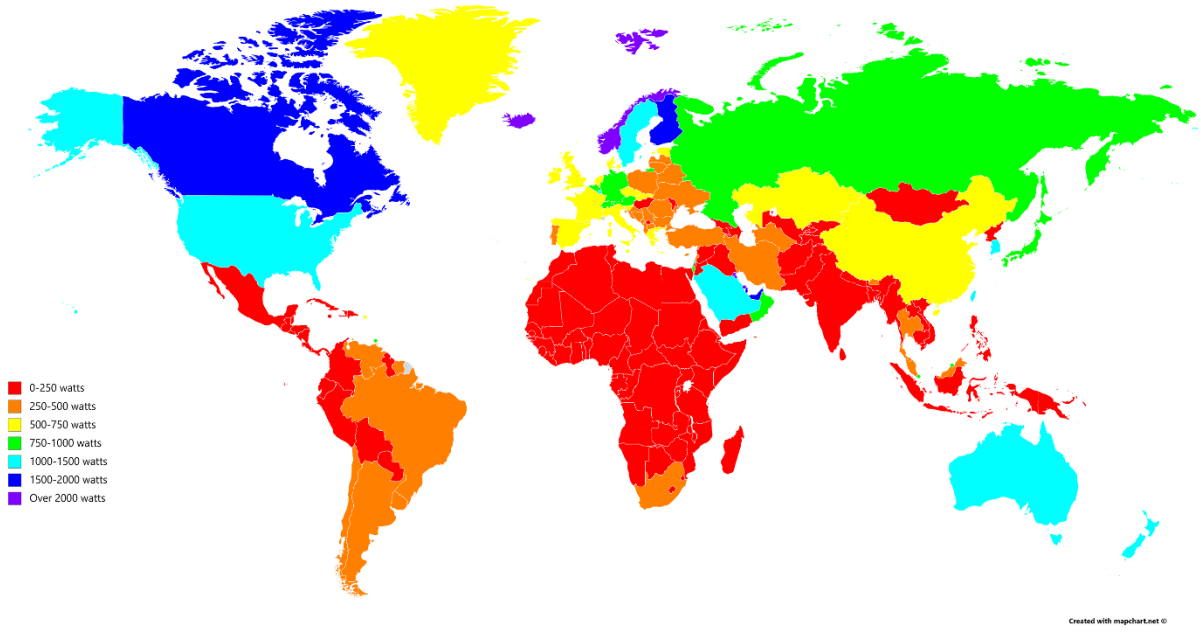


Figure 4.1: Energy consumption per person

If we look closely, nations like African coast, India, Brazil are some of the countries where the energy consumption is 250 watts per person where on the other hand Canada, Netherlands, USA, Australia are some of the examples where the energy consumption is around 1000 watts per person. This does shows that developed countries consume more countries than developing

countries. But that is not the case in every country, if we look at Europe, the energy consumption is low, so it all comes down to the strategies we use to reduce this consumption.

How much are we dependent on these resources? Let's have a look at Figure 4.2 for the answer to this question.

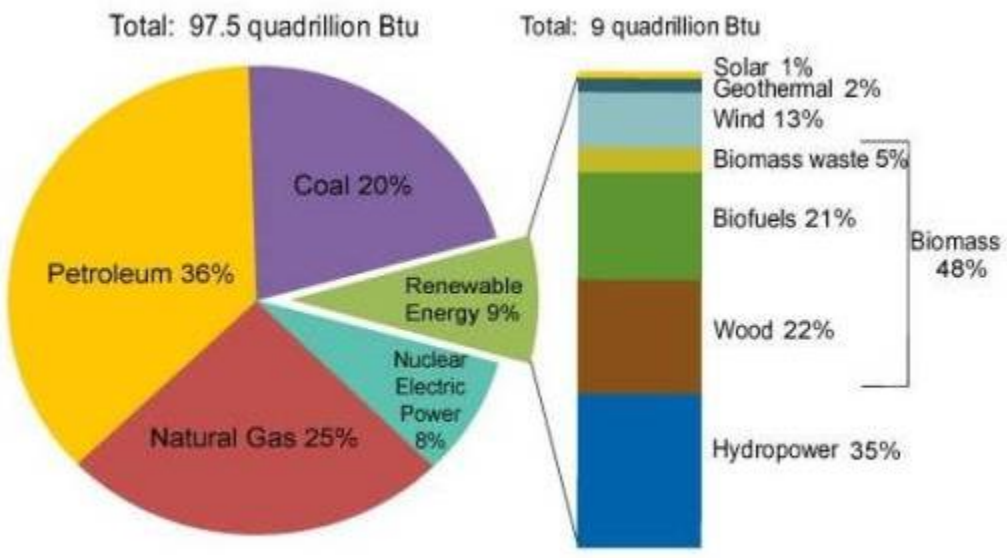


Figure 4.2: Different energy resources and their usage in percentage

So, as the pie chart shows we are basically living on non-renewable energy. We use approx. 89 percent of these resources to fulfill our energy needs, rest of the energy is fulfilled by renewable sources like hydro, wind, biofuels, and wood.

Let's look at some energy resources and their effect on our environment.

Oil

Let's consider an example from the past. From early eighteenth-century people used to hunt whales for the oil they make in their bodies and it is renewable because whales reproduce. But when the energy needs increased overharvesting of whales was faced and due to that and some moral ethics, hunting of whales was prohibited and now we needed a new source of oil for our energy needs. But this was not the only reason why we shifted from whale oil to oil. The main reason was that oil was much easily extractable than whale oil and it was cheaper. This

discovery of oil led us to be entirely dependent on oil and as a result 94 percent of US energy needs are fulfilled by oil. So, if we are going to run out of oil in near future than we should have a backup which can provide us the same efficiency in the same amount or cheaper. Sometimes it is just human nature to be dependent on a particular object until you can see that object is going to lose its existence then he goes on the hunt for another dependency. So, right now our greatest concern is not about the environment because we are already running out of our primary energy resource and it is important to find a new one which is right on our expectations. If we know that oil is going to end than we can estimate when. And there is going to be a peak point after that we are going to face continuous decline in our oil extraction. We call this point as peak oil and if a country reaches to its peak oil position than they are at verge of extinction of the resource. Looking at Figure 4.3 makes it easy to understand.

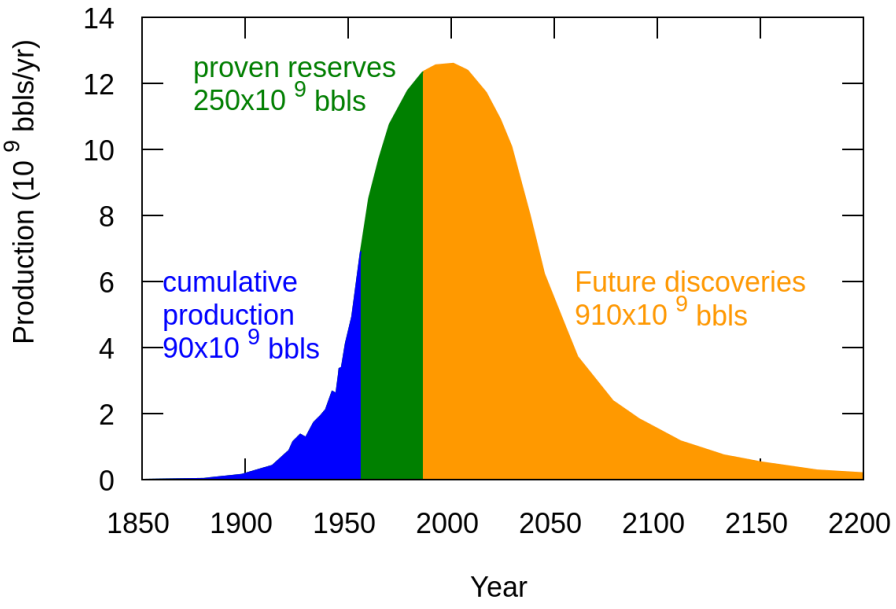


Figure 4.3: Peak oil model

But if we look economically after the peak oil the oil is going to get harder and harder to extract and expensive side by side. After a significant amount of time it will be economically feasible to extract oil but still after early estimates we can still enjoy it till the end of the decade.

EROEI

EROEI stands for energy returned over energy invested. At first when we were extracting oil it was easy to extract because it was on the surface. If we say it like this then at the cost of 1 barrel of oil we were able to extract 100 barrels of oil but as soon as the extraction took it's speed, it became harder to extract and according to current rate we only get 10 barrels on the investment of 1 barrel and economically it is a disaster. This is just a beginning. What if after some decades we are getting and EROEI of one. Well, its not worth the effort. If we are not getting anything in return than it's not a safe investment or a profitable one. We must find other resources. Coal and natural gas look promising. Are they going to end?

Coal & Gas

After oil, the only resources we use in majority for our energy needs is coal and there are so many reasons for this. Coal is cheap, much easy to extract, gives a 100 percent energy return on energy invested and most of it is available where oil isn't. Second resources which fulfill our energy needs is natural gas which can be directly used, we don't have to wait for sun or wind for it. Both natural gas and coal are used in industrial supplies and are going to utilized in future until it vanishes. However, coal has its own disadvantages. First is it produces more CO_2 than any other resources discovered and used. Second it causes acid rain, sludge, contamination. We are now using coal less and less because we have reached the peak for coal in 1998 and estimate is that we are going to run out of coal in next century. The main issue with coal is not we are going to run out of it, pollution is the one stands out. There is another resource which produces less carbon dioxide however it gives less energy return but still a good alternative. It is natural gas and at first it was estimated that it was also going to run out in 50 years but after some technical advancements we have estimated 200 years. But the main problem with natural gas it that it still produces carbon dioxide, and these three resources gives approximately 80 to 90 percent of energy. Can we shift to other resources without depending on these non-renewable resources? Let's look at other alternatives.

Nuclear Power

There is another alternative which produces a less amount of carbon dioxide and cheap, not as cheap as coal but competitive. Nuclear power is a great source of energy and many countries are using it as their mass energy resource already while some countries does not even start the tests. The problem with nuclear power is security issues and fear of contamination. But this issue is not faced by most of the countries like USA have never faced a single death because of nuclear hazards. But another issue with nuclear power is there. Nuclear power is produced with help of radioactive substances which are extracted from earth and this does tell us that it's a non-renewable resource. Some estimates suggest that it already reached to its peak in 1980s while others say that we might hit the peak in 2035. There is another issue with this energy resources and that is NIMBY known as not in my backyard. Because of nuclear hazards and radioactive radiation there is no public support for this. So, we have found a resource which produces a smaller number of carbon dioxide but still not useful for use due to health issues. Can we find solution for this?

Renewable Energy

What is a perfect energy source? If we consider our every need than it should be efficient, with no pollution, cheap, easily available and zero health issues. But the world is not perfect. We can't have all these things in one source. We saw that with fossil fuels we can get efficiency, but we are also getting pollution and they are going to run out, we also saw with nuclear power we had health issues and no public support. So, by moving to renewable energy we can avoid these issues. The most used energy resource in this category is hydroelectricity, it is not a very difficult technology and we are now using it for decades but the one thing that is wrong with hydroelectricity is it changes ecosystem of water and thus causes more deaths of water animals. Because of this people decided to stop these dams and save those local ecosystems. Another alternative is solar and wind power which are still growing but they are great and easy to assemble things. We can still rely on them, but they are evolving, and we can see much more potential in future but now they cannot fulfill our needs. And most of it so much expensive that a normal person can't think of buying solar panels where for wind energy we require special places which are enrich with wind. So, for now if we are going to rely on renewable resources than it is going to cost a fortune. Some experts suggest that rather looking for new sources to use we must use less of the already available.

Energy conservation

we have now read about the energy resources both renewable and non-renewable and we know we could use them but the main thing is if we reduce the power usage than the time span of there existence is going to expand. Like, if we use LED bulbs in place of fluorescent bulbs or incandescent bulbs, we are saving more energy than ever. We can build more efficient heating or cooling system we can add insulation in the buildings. We can reduce the energy we use and the cost of the energy we use. There is also a problem with more efficiency, we tend to use it more. The more efficient the source is the more we are going to use it and the price is going to be sky high.

We looked at energy and the advantages and disadvantages attached with them. But do you think this is the only problem with the world? When we talk about the major issues in this world, sustainability does not come first. Hunger, the one thing that is the major issue. Are we producing enough food to feed each person in this world?

CHAPTER 5

WATER
&
AGRICULTURE

In this chapter we are going to study about the two most important things which is pretty much the source for human body of energy. Water and Agriculture, these two things which are interconnected, and we are most of the time dependent on agriculture.

Water

If we look at earth from space, we can see that it is a world of water and despite of that we are running out of it. We need water to drink, our daily utilities like washing, cooking etc. water is also used for power generation, industries, and agriculture. Water is renewable still we are using it unsustainably. How is that possible? We can't use water that is available in oceans because of most minerals which are excessively harmful for our body and mostly useless. The water we are dependent upon is the water which runs underneath us also know as ground water and we can estimate the usage of this water which can be considered the sustainable still we are using excess of it.

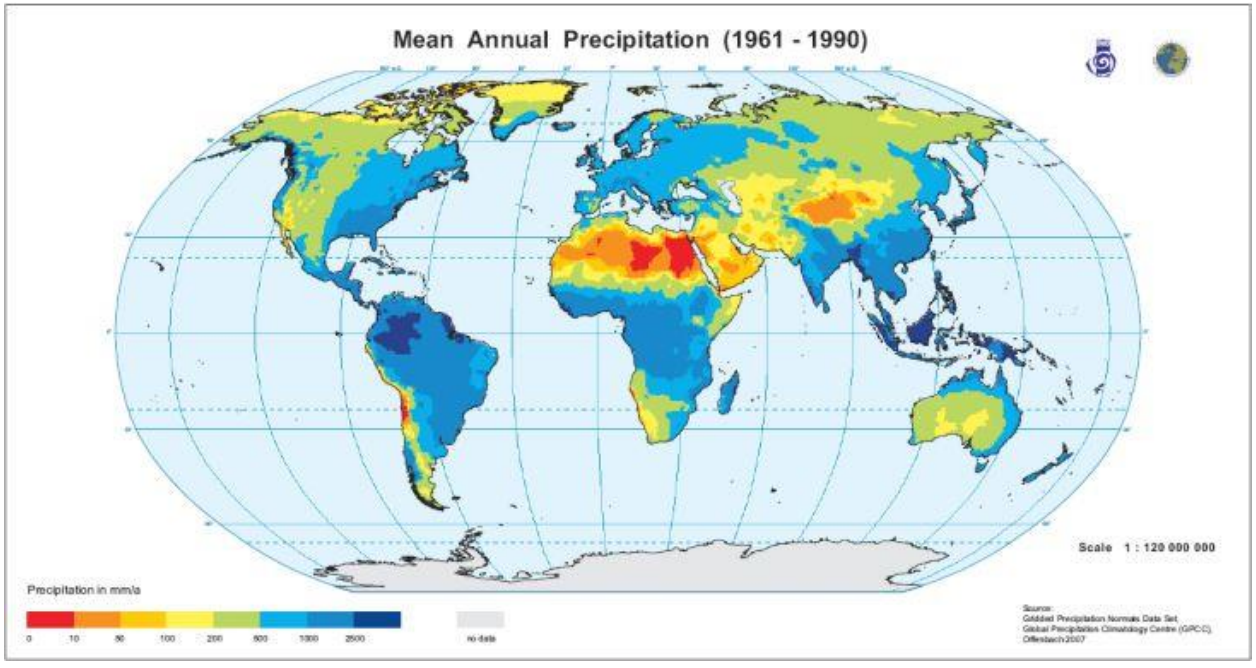


Figure 5.1: Water precipitation

if we look at the world map in above figure, we can identify the water rich countries and the water poor countries. Now if we are using the groundwater for our needs we have to find out where it exists and the above figure is helpful in it. But we are going to use the excessive

groundwater than the rate it is reproducing than the groundwater level is going to get down which is then hard to extract and the deeper the water the older it is.

We use water for our daily needs and in industries but most of the water is used agriculture and it is more important to feed people in this world and as the population is increasing we need more and more food hence we need to increase our agriculture and as a result the usage of water is going to increase and in present we are using our water unsustainably, what do you think would happen in the future? As a result, we are going to see the water level going down and harder to extract ground water and the more effort it requires to extract the water more the price of affording the water. Human is trying day by day to resolve this problem but for an individual this is a major task, we need countries to contribute solutions in this tragedy. We will now see how all the countries can contribute in this.

Water trends

How much water are we using? Well if we look at the water that we can see we are still using excess of it but this not the only water we are using. There is water embedded in things we use in our daily life. what is embedded water? Embedded water is the water used to produce that element and make it what its supposed to be. This embedded water is also known as virtual water. A type of water that we can't see but still is used to produce stuff. But this is not the case, we have water rich countries which export things made with the use of water to the water poor countries like Yemen, where is shortage of water. Yemen is a country where water availability per person is 200 cubic meters where UN suggests that every person should have a water availability of 1000 cubic meters per year. And as we have seen Yemen is a country with great population growth and has a potential to have a great population in near future. And if this is the scenario than the water stress is only going to increase in Yemen. But most of the places are not like Yemen and still they are using their water in unsustainable manner. Another issue that we have seen in Yemen scenario is water pollution. If pollute an aquifer than it is equivalent to removing it from the water table. Most of the human activities like agriculture and industrial pollute the water. Another serios issue with water usage is sanitation. Most of the people who use excessive water just ignore the importance of cleaning it. People use water for sanitation but in a way that they do not understand the need of cleaning it and most of the places in india just use these resources as toilets or bathrooms. They wash their clothes in these

resources, bath their cattle and themselves and use them as toilets as well. This leads us to increase the water stress in our country. We need clean water to clear this water and we need water for agriculture and industries. We need policies to work on and to obey in order to get our water needs without any problem.

Agriculture & Food

Most of the countries are depended on cheap food and when these food prices go high it causes civil unrest. Giving this situation and as we know we must produce more food in the future and giving the situation we are going to face more food riots than ever. More population and less production mean more people are hungry. So, to fulfill their energy needs we must increase the agriculture production. We need to increase this production by 1.5% but as we have seen population is growing 1 percent per year then why this big amount is to be increased? Well, food consumption depends on how wealthier a person is. The poor uses less food than the rich one. So, as a country become richer it's food consumption rate also becomes higher. Its not about how much we eat, its about how much the wealthier person spends on the food quality and how much one spends on it and how much one throws away irresponsibly because it is their property. So, we can notice the wealthier the country more food wastage is going to be there. So far, we can fulfill all of these needs, but it is going to create difficulties in future though. Let's look if we can feed another 2 billion people in future or not.

How are we going to increase our agricultural strength? To do that we have to convert more of the virgin land into farmland but according to estimates we can only convert 10 percent of the virgin land into mass land in present. But that's not enough and it is also going to disturb the natural ecosystem. Another issue is that more crops need more water, and more crop means higher the demand and higher the price. Rich country consumer does not care about the little raise in prices, but it does effect the people below poverty line. But for the past few years we have seen that prices are low and the reason behind it is modern farming. Which uses new equipment and techniques which are derived from the older techniques but less human effort. This lowers the price but not for so long. But we can say that because of this modern farming techniques we have much higher yields and this is why we have not faced Malthusian condition until now and in future if we want to avoid Malthusian condition than we have to increase

yields. So, instead of creating more lands we must focus on increasing the yields. And if this type of farming is sustainable than we can easily feed people and avoid Malthusian catastrophe.

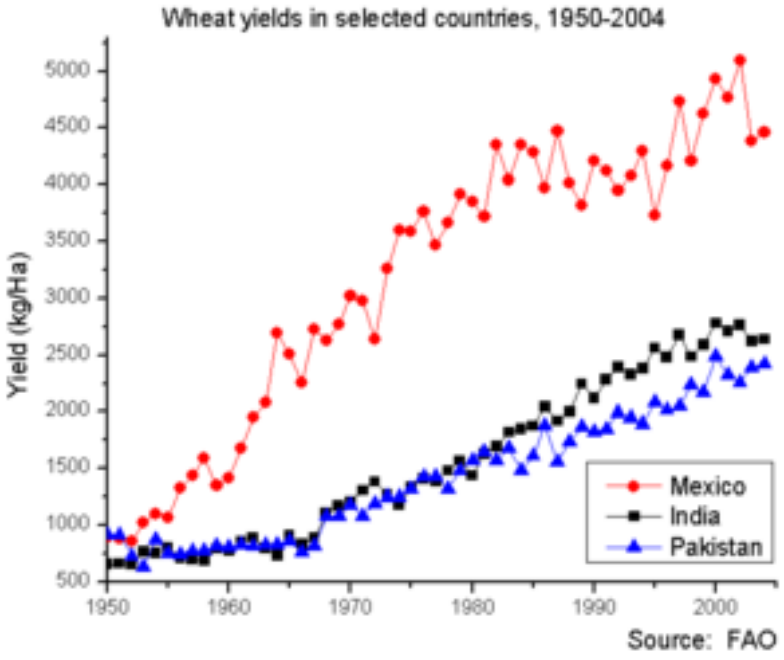


Figure 5.2: Crop yields in Pakistan, India, and Mexico

As we can see in above figure in developing countries like India, Pakistan, and Mexico from the past few years the crop yield is continuously increasing. So, the yield is not only increased in developed countries, but it also increased in developing countries also. What caused this increase? Well, the green revolution which focused on chemical fertilizer, irrigation and pesticides increased the yield but because of this result we have seen more and more amount of chemicals are used in crops. These fertilizers were connected to fossil fuels and because of this we can't say that it was a sustainable idea. Excess use of these fertilizers has shown that it is also harmful for local ecosystems and interferes in natural growth of crops. So, does this mean we have to go back to pre-green revolutions techniques? To feed the upcoming extra billion or two billion people we must use these new techniques. These are some serious tradeoffs.

CHAPTER 6

ENVIRONMENTAL POLICIES

We have seen to make the earth a sustainable place we considered some changes and most of the time we have considered some technological changes. Another type of changes we can apply are the changes in policy. Good policies require natural understanding as well as social understanding.

Negative Externalities

In sense of environmental economics, negative externality means that the negative impact on people which are not involved in the activity caused by some other person or organization. Not all externalities are negative though, if you work is causing people benefit in their health or wealth than it is considered as positive externality. We are not focusing on personal benefits rather than the focus is shifted on total net benefit. Total net benefit is considered as the impact of the activity on everyone and everything that includes in that system.

Environmental policy

As we've seen, the world faces several environmental problems, and the clear humans are not managing these problems as well as they could. In the tragedy of the commons examples we saw many natural systems that was suffering because human societies are systematically unsustainable. So, the goal of policy then is to correct this systematic unsustainable element and return us to a more sustainable path.

For example, if we need to apply policies to improve air quality, we can reduce smoke fields, use chimney in factories and in our houses etc. How to do we sort these policies from each other. To say precisely, there are two broad categories, the first one is command and control legislation and the second one is market incentive legislation.

Command and control as the name suggest tells people and organizations what to do. So, in command and control there is a set of limits that must be met and then it is upon the individual or an organization how to follow them. the second one, market incentives suggests that an individual or an organization will lower the pollutant emissions or follow the regulations until this is economically feasible for them. Market-based incentive instruments may be broadly

classified to include environmental taxes, investment tax incentives, tradeable permits, user charges and deposit refund systems.

CHAPTER 7

BIODIVERSITY
&
ECOSYSTEM

Biodiversity and ecosystems

What is biodiversity and how does it affect sustainability? To begin with biodiversity can be considered as the variability among living organisms from all sources including terrestrial, marine, and other ecosystems and the ecological complexes of which they are part. As human is developing and making more and more man-made infrastructure day by day, it is destroying the natural habitat and killing non-human beings which does affect biodiversity. And biodiversity which is helpful for food chain, which provides resilience for climate change and thus supports sustainability. It also takes care of human health and provide jobs in agriculture, fishery and many more areas.

Sustainability metrics

Sustainability metrics and indices are measures of sustainability, and attempt to quantify beyond the generic concept. Though there are disagreements among those from different disciplines, these disciplines and international organizations have each offered measures or indicators of how to measure the concept.

The "Daily rules" Approach

1. Renewable resources such as fish, soil, and groundwater must be used no faster than the rate at which they regenerate.
2. Nonrenewable resources such as minerals and fossil fuels must be used no faster than renewable substitutes for them can be put into place.
3. Pollution and wastes must be emitted no faster than natural systems can absorb them, recycle them, or render them harmless.

Environmental footprint

the effect that a person, company, activity, etc. has on the environment, for example the amount of natural resources that they use and the amount of harmful gases that they produce. Also referred to as an ecological footprint, this is a measure that attempts to consider multiple impacts of an activity rather than focus on one. In relation to the swine industry, this footprint considers the results of carbon, water, land and air footprints of pig farming.

Carbon Footprint

Environmental footprint is a good example for measuring sustainability, but we need a more specific footprint to examine the sustainability metrics for an individual. Here come in picture – "Carbon Footprint". A carbon footprint is the amount of greenhouse gases—primarily carbon dioxide—released into the atmosphere by a particular human activity. A carbon footprint can be a broad measure or be applied to the actions of an individual, a family, an event, an organization, or even an entire nation. It is usually measured as tons of CO_2 emitted per year, a number that can be supplemented by tons of CO_2-equivalent gases, including methane, nitrous oxide, and other greenhouse gases.

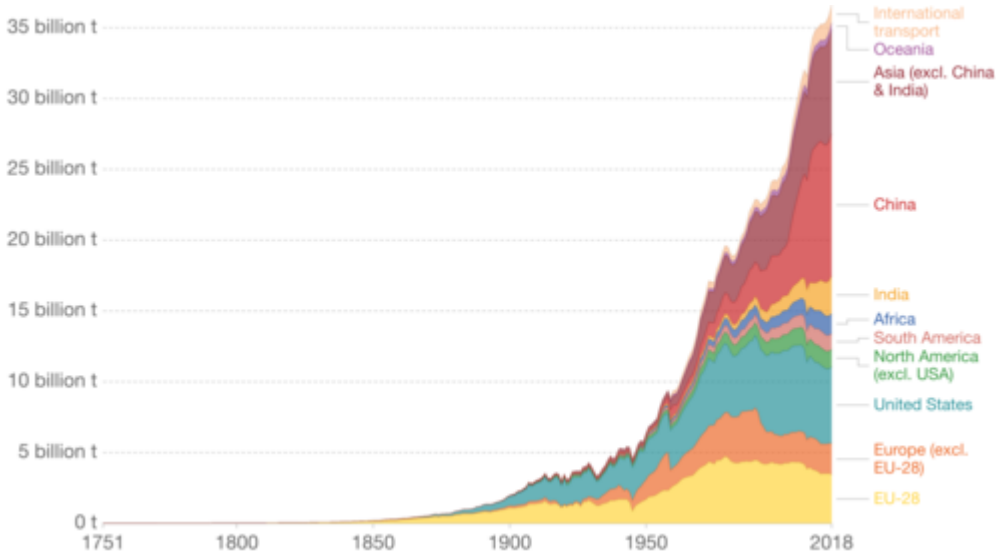


Figure 7.1: CO_2 emissions according to countries

If we look at figure 7.1, we can find that the two countries with the most emission is the united states of America and China where India is not contributing much to the whole emission. Here if we see in USA half of the emission occurs in industry but the other half is the issue that carbon footprint does not show. As we have seen many products have virtual water embedded in them. Same applies for carbon dioxide which is used or emitted in the process which carbon footprint cannot predict accurately. So, when we look at our carbon footprints its not just the gases which we emit when using the products or fossil fuels but it is also the things which have

carbon dioxide or energy embedded in them. So, to deal with this issue we assess these products with life cycle assessment.

Life cycle assessment

Life cycle assessment is a cradle-to-grave or cradle-to-cradle analysis technique to assess environmental impacts associated with all the stages of a product's life, which is from raw material extraction through materials processing, manufacture, distribution, and use.

1. compiling an inventory of relevant inputs and outputs,
2. evaluating the potential environmental impacts associated with those inputs and outputs,
3. interpreting the results of the inventory and impact phases in relation to the objectives of the study.

CHAPTER 8

CONCLUSION

Sustainable Future?

As we have seen in this report about many aspects and techniques that affect sustainability and past data. So, now we are able to predict the future in reference to sustainability. Where are we headed? As we have seen in starting of this report and learned about two type of curves – J-shaped and S-shaped. Which growth curve does this generation follow? If we see in developed countries like USA, they have shown an impressive growth in this field, as the population is increasing, they have lower greenhouse gas emissions as well as better agriculture. On the other hand, if we look on developing countries like India, we still see the gradual growth but not enough to say that it's safe. If we talk about other things in developed countries than they have also reduced the water usage per person and they have also used farmlands more efficiently. Although the population was still increasing in exponential way. There is also less travel and less material goods selling than ever. So, this does tell us about the wealth and pollution relation about a country. Look at Figure 7.2 which shows environmental Kuznets curve and will help us to understand.

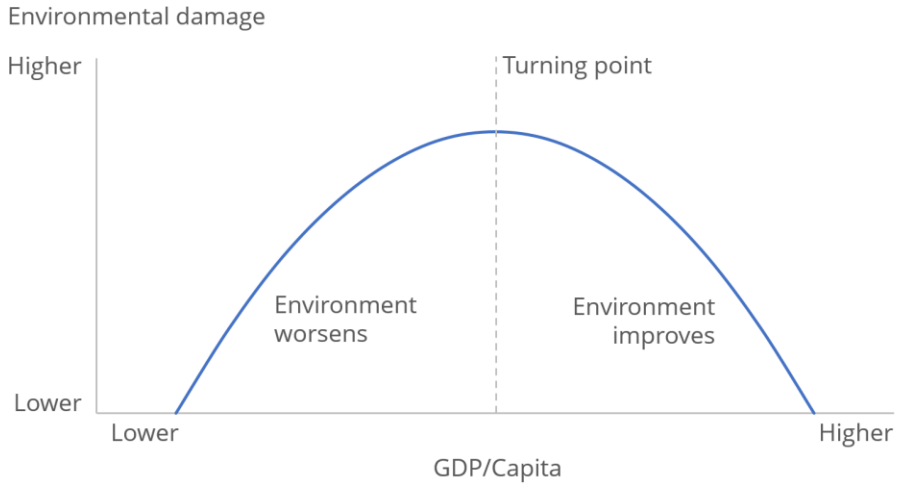


Figure 8.1: Environmental Kuznets Curve

This curve tells us that more the countries will get developed more we are going to see improvement in our environment and more we are going to move towards sustainability. sulfur

dioxide emission curve does helps us to understand this. But the Kuznets curve does not apply at every aspect. We can see that more the country becomes wealthier their calorie consumption also goes higher. This goes same for carbon dioxide emission. So, does this mean that we are on J-curve? Because at one hand we see some serious decline in developed country and some Kuznets curves but on the other hand we saw the main issues are still increasing day by day. There is starvation in some countries, CO_2 emissions and agricultural production. But if we look closely that is not the only thing that could lead us to Malthusian catastrophe. Some human activities like nuclear war are also sufficient for a worldwide crop failure. Another example that comes in mind is climate change which is about to cause the world starvation. In both cases amount of yield will crash. So, are we in a condition where a disease or a disaster would take place, and all of this will turn into ashes? It does not seem likely. Because although there many fragile monoculture ecosystems if we see the worldwide picture it's still biodiverse. So, does this mean we can still imagine S-curve for earth? Well, not now but in the future, it seems likely that we can still manage everything though it is expensive but still manageable one of the reasons is world's population is not on a J style trajectory. So, if things went fine, we would be able to find new agriculture techniques, new energy systems, to new water management systems etc. So, we would be able to be resourceful in near future if we are heading on the same path which are on right now.