UNIT – I

Sustainable Development

- Introduction to sustainable development - Economy-Environment interlinkages - Meaning of sustainable development - Limits to growth and the environmental Kuznets curve – The sustainability debate - Issues of energy and the economics of energy – Nonrenewable energy, scarcity, optimal resources, back stop technology, property research, externalities, and the Conversion of uncertainty.

Introduction to sustainable development

- Development which meets the needs of the present without compromising the ability of future generations to meet their own needs'.

- This most widely accepted definition of Sustainable Development was given by the Brundt land Commission in its report Our Common Future (1987).

- Sustainable development (SD) calls for concerted efforts towards building an inclusive, sustainable and resilient future for people and planet.

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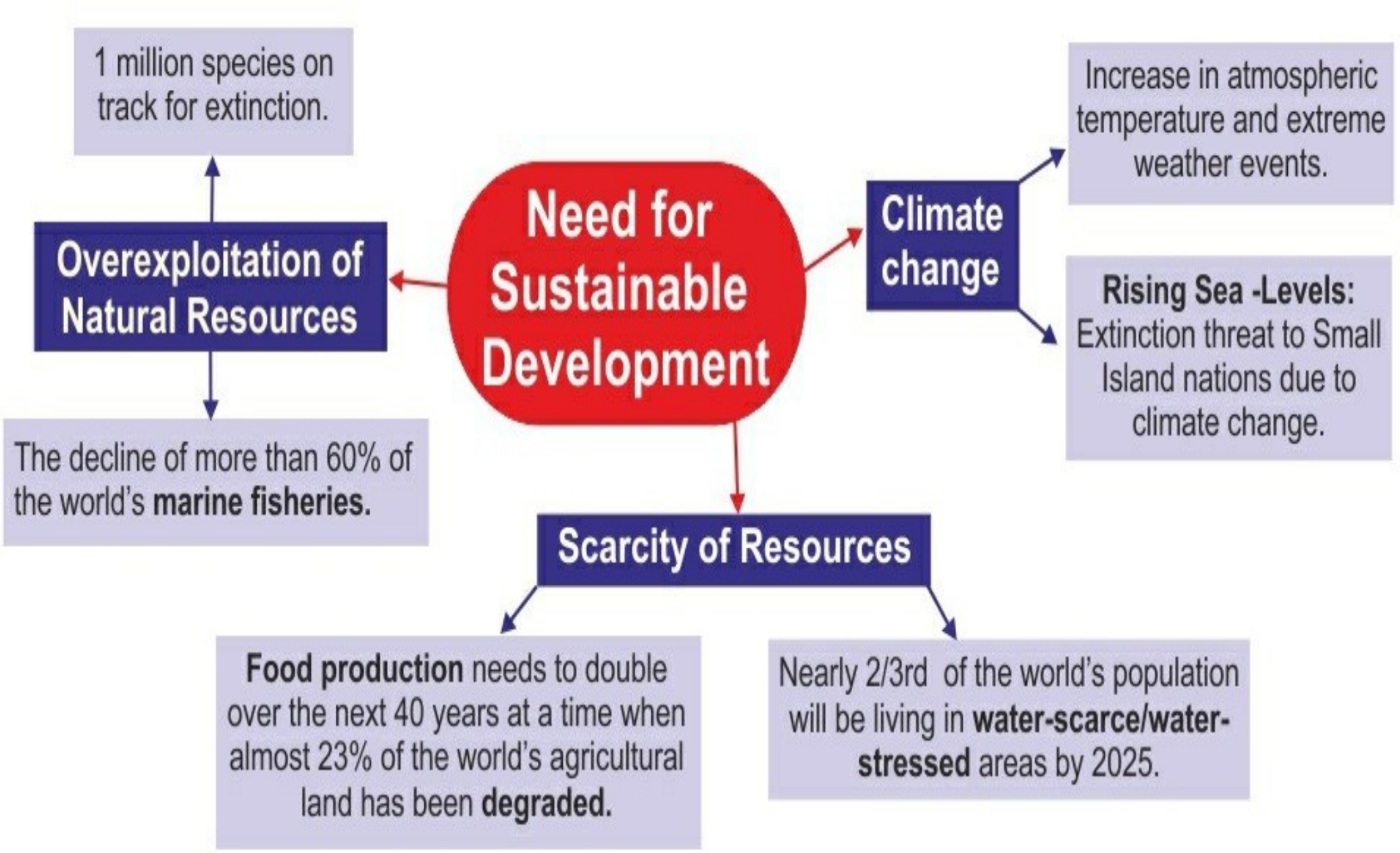

Need for Sustainable Development
Overexploitation of Natural Resources
1 million species on track for extinction.
The decline of more than 60% of the world's marine fisheries.
Climate change
Increase in atmospheric temperature and extreme weather events.
Rising Sea -Levels: Extinction threat to Small Island nations due to climate change.
Scarcity of Resources
Food production needs to double over the next 40 years at a time when almost 23% of the world's agricultural land has been degraded.
Nearly 2/3rd of the world's population will be living in water-scarce/water-stressed areas by 2025.

Core elements of sustainable development

•Three core elements of sustainable development are economic growth, social inclusion and environmental protection. It is crucial to harmonize them.

•Sustainable economic growth, achieving sustainable livelihood, living in harmony with nature and appropriate technology are important for sustainable development.

•**Environmental Sustainability:**
It prevents nature from being used as an inexhaustible source of resources and ensures its protection and rational use.
Aspects such as environmental conservation, investment in renewable energy, saving water, supporting sustainable mobility, and innovation in sustainable construction and architecture, contribute to achieving environmental sustainability on several fronts.

cont

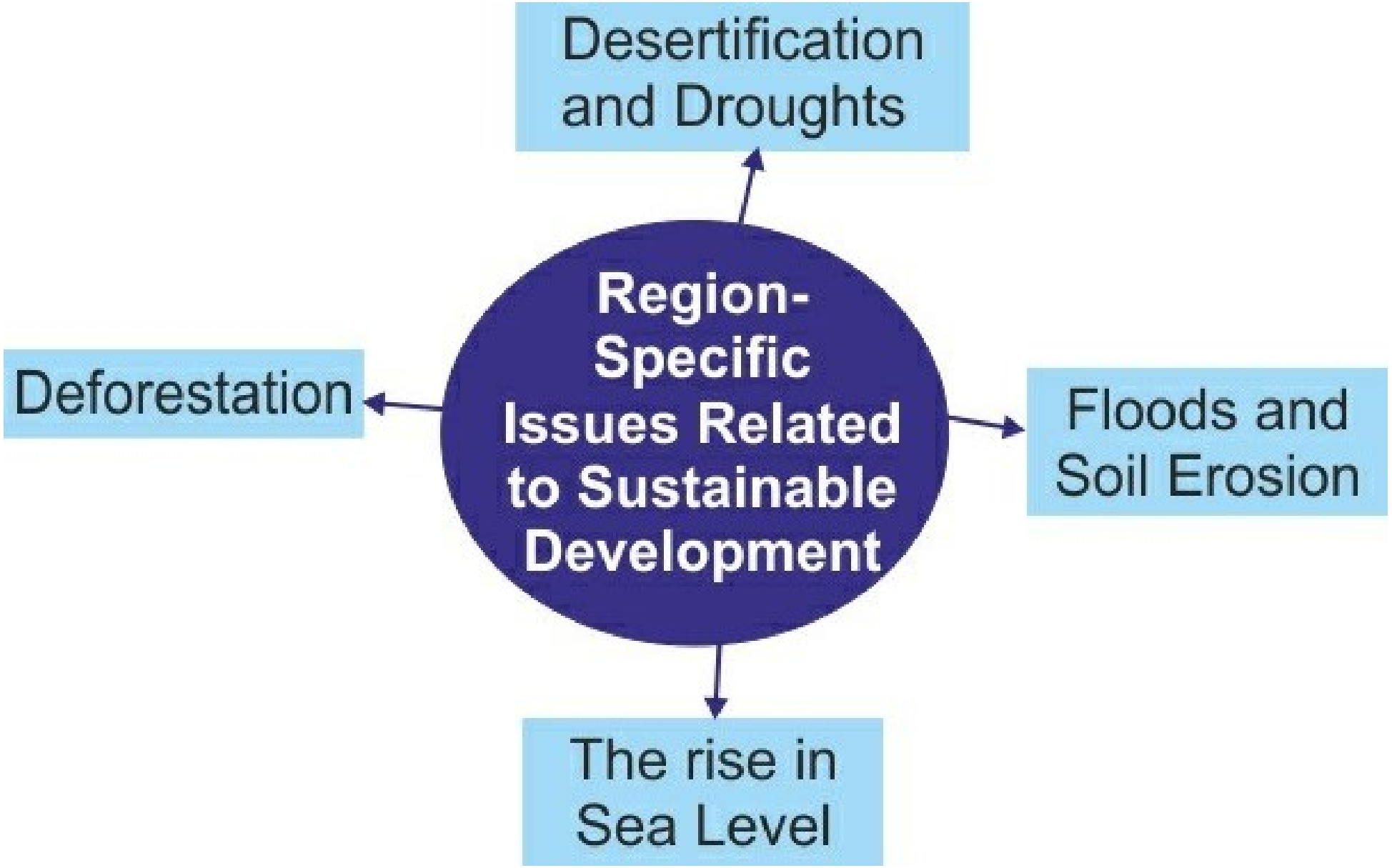
- **Social Sustainability:**

It can faster gender equality, development of people, communities and cultures to help achieve a reasonable and fairly-distributed quality of life, healthcare and education across the Globe.

- **Economic Sustainability:**

Focuses on equal economic growth that generates wealth for all, without harming the environment. Investment and equal distribution of economic resources. Eradicating poverty in all its forms and dimensions.

Global issues Related to Sustainable Development



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- Inequitable growth of national economies (North-South Divide)
- **Loss of Biodiversity:** Despite mounting efforts over the past 20 years, the loss of the world's biodiversity continues.
- **Climate Change:** As a global problem, climate change requires a global solution. Within climate change, particular attention needs to be paid to the unique challenges facing developing countries. Tackling climate change and fostering sustainable development are two mutually reinforcing issues.
- **Intellectual Property Rights (IPRs):** There is a need for welfare for all rich and poor to have affordable access to the results of innovation that can lead to sustainable development.

Global Initiatives on Sustainable Development

- **The Stockholm Conference,1972:** It was the first step towards putting environmental concerns on the global agenda. It resulted in the Stockholm Declaration which contained principles and an Action Plan containing recommendations for environmental policy.

- **UNEP** was set up in 1972 to serve as a catalyst in developing and coordinating an environmental focus in the programmes of other organisations.

- **The Earth Summit, 1992**: This was a direct consequence of the Brundtland Commission's Report. It was held in Rio de Janeiro. The results of the Conference were the following documents: The Framework Convention on Climate Change (UNFCCC) The Convention on Biological Diversity The Statement on Forest Principles The Rio Declaration Agenda 21

Global Initiatives on Sustainable Development

•**Kyoto Protocol,1997 Rio +10, 2002:** A 10-year assessment of the Rio outcomes (Rio +10) took the shape of the World Summit on Sustainable Development (WSSD) held in Johannesburg.

•**Ramsar Convention, 1971 The World Heritage Convention, 1972:** It identifies and conserves the world's cultural and natural heritage. It draws up a list of 'heritage sites', which are cultural, natural or mixed areas of 'outstanding universal value' and therefore need to be preserved for all humanity.

•**Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973**

•**Convention on the Conservation of Migratory Species of Wild Animals (CMS), 1979.**

•**Vienna Convention for the Protection of the Ozone Layer, 1985**

•**Montreal Protocol on Substances that Deplete the Ozone Layer, 1987**

Global Initiatives on Sustainable Development

- **Basel Convention, 1989 Convention on Biological Diversity,1992**
- **United Nations Convention to Combat Desertification,1994**
- **Rotterdam Convention,1998**
- **Stockholm Convention on Persistent Organic Pollutants,2001**
- **Global Tiger Forum,1993**
- **International Whaling Commission,1946**
- **Minamata Convention,2013**
- **Climate change mitigation strategies: Carbon sequestration, Carbon sink, Carbon Credit, Carbon trading, Carbon offsetting, Carbon Tax, Geo-engineering.**
- **United Nations Environment Programme (UNEP)**
- **UN Commission on Sustainable Development (CSD)**
- **United Nations Convention on the Law of the Sea (UNCLOS)**
- **Climate Finance Architecture**: Green Climate Fund (GCF), Adaptation Fund (AF) and Global Environment Facility (GEF)
- **Reducing Emissions from Deforestation and Forest Degradation (REDD) and REDD+**
- **Paris Agreement 2015**

Sustainable Development Goals (SDGs)

•To bring sustainable development in the mainstream United Nations (UN) launched the 2030 Agenda for Sustainable Development and SDGs.

•This universal, integrated and transformative agenda aims to spur actions that will end poverty and build a more sustainable world over the next 15 years.

• There are 17 goals and 169 targets specific targets to be achieved by 2030.

•Reaching the goals requires action on all fronts – governments, businesses, civil society and people everywhere all have a role to play. SDGs are not legally binding.

Sustainable Development Goals (SDGs)

Regional Initiatives

•Regional mechanisms are effective means for addressing trans-boundary issues such as atmospheric pollution and pollution of shared rivers and water bodies, which nations are unable to solve on their own. Regional mechanisms involve fewer transactional costs, are less time-taking and have higher chances of success.

• **The European Union (EU):** It enforced certain environmental principles viz., preventive principle, subsidiarity principle, integrative principle, the polluter pays principle etc.

•**ASEAN** has numerous environmental legal instruments.

•**SAARC adopted Environment Action Plan (1997):** Comprehensive Framework on Disaster Management 2006-2015 was adopted in 2006 to address the specific needs of disaster risk reduction and management in South Asia. SAARC Convention on Cooperation on Environment has been ratified by all member states and entered into force in 2013.

Community Initiatives

•A significant initiative towards sustainable development comes directly from the community level. NGOs create linkages between global and local needs and actors. They have played a role in negotiation, monitoring and implementation of environmental law and policy at all levels.

•**IUCN, 1948** has helped draft or has provided a secretariat for several important international conventions.

•**National Greenhouse Gas Inventories Programme (IPCC-NGGIP**)

•**The WWF** has played a major role in the evolution of the international conservation movement.

•**TRAFFIC:** The Wildlife Trade Monitoring Network,1976

Role of Cooperatives in sustainable development

- Cooperative societies connect the people at the grassroots level to the highest level of the government.

- Cooperatives and NGOs help considerably in the up liftment of the socio-economic conditions of the rural poor and also adopt environment-friendly technologies for their functioning and generate awareness among people regarding environmental issues.

- Ex: In India, AMUL became the most successful cooperative movement for the sustainable development of rural poor by launching the Operation Flood.

Progress

- **As per the Sustainable Development Goals Report, 2019**

- Extreme poverty has declined considerably. The under-5 mortality rate fell by 49 % between 2000 and 2017.
-
- Immunizations have saved millions of lives. The vast majority of the world's population now has access to electricity.

- Countries are taking concrete actions to protect our planet: marine protected areas have doubled since 2010.

- Countries are making concerted efforts to address illegal fishing.

- 186 parties have ratified the Paris Agreement on climate change, and almost all have communicated their first nationally determined contributions.

Progress

•About 150 countries have developed national policies to respond to the challenges of rapid urbanization, and more than 70 countries and the European Union now have more than 300 policies and instruments supporting sustainable consumption and production.

• A wide range of other actors—international organizations, businesses, local authorities, the scientific community and civil society— have engaged with the SDGs in a manner that generates great hope for the coming decade.

challenges

- **As per the Sustainable Development Goals Report, 2019**

- Increasing inequality among and within countries requires urgent attention.

- 3 out of every 4 stunted children live in Southern Asia and subSaharan Africa.

- Young people are more likely to be unemployed than adults.

- Barriers in achieving gender equality.

- Global hunger has been on the rise after a prolonged decline.

- Extreme poverty declined from 36% in 1990 to 8.6% in 2018, but the pace of poverty reduction is starting to decelerate as the world struggles to respond to entrenched deprivation, violent conflicts and vulnerabilities to natural disasters.

challenges

•Extreme poverty is three times higher in rural areas than in urban areas.

•2018 was the fourth warmest year on record. Levels of CO2 concentrations continued to increase in 2018.

•Natural environment is deteriorating at an alarming rate.

•Sea levels are rising.

•Ocean acidification is accelerating. Ocean acidity is 26% higher than in pre-industrial times.

• 1 million plant and animal species are at risk of extinction.

•Land degradation continues unchecked.

Various methodologies have been evolved to monitor the progress of SDGs.

- **Sustainable Development Index (SDI), 2019**

• It is released by the Sustainable Development Solutions Network (SDSN).The SDI seeks to help countries identify gaps that must be closed in order to achieve SDGs by 2030 and to identify priorities for early action. India ranked 115 out of 162 countries.

- **Global Sustainable Development Report (GSDR), 2019**

• It is the first GSDR prepared by the United Nations. It is entitled "The Future is Now: Science for Achieving Sustainable Development". It evaluated progress on the 2030 Sustainable Development Agenda. The amount of modern renewable energy in the total global energy supply has increased by an average of approx. 5% annually over the past decade. Meanwhile, since 2009 the price of renewable electricity (solar and wind) has dropped for five years in a row.

ECONOMIC ENVIRONMENT

- Economic Environment refers to all those economic factors, which have a bearing on the functioning of a business. Business depends on the economic environment for all the needed inputs.
- It also depends on the economic environment to sell the finished goods. Naturally, the dependence of business on the economic environment is total and is not surprising because, as it is rightly said, business is one unit of the total economy.

IMPORTANCE OF ECONOMIC ENVIRONMENT

- Managers assess economic environment and forecast market trends in the effort to make better investment choices and competitive strategies.
- Economic analysis look at several indicators of an economic environment with emphasis given to how local conditions require adjusting analysis and interpratation.
- The economic environments of foreign companies and markets can help managers predict events that might affect the company's future performance.

ELEMENTS OF ECONOMIC ENVIRONMENT

- GROSS NATIONAL INCOME:

  the income generated both by total domestic production as well as the international production activities of national companies.

  GROSS DOMESTIC PRODUCT:

  the total value of all final goods and services produced in a country in a given year equal to total consumer, investment, and government spending, plus the value of exports, minus the value of imports.

- **PER CAPITA CONVERSION**:

  The per capita GNI is taking GNI of a country and converting it into a standard currency say at US DOLLARS at prevailing market rates and then dividing this sum by its population leads to a Per Capita Conversion estimator.

  it helps to explain an economy's performance in terms of people who live in that country.

3. Rate Of Change

- GDP growth rate indicates a country's economic potential.
- High GDP rate means rising standard of living
- Business opportunites
- Example- China has been one of the fastest growing economies over the past 2 decades, which attracted an immense amount of FDI.
- The developing countries like China and India have a higher growth rate than the US

4. Purchasing Power Parity

- The purchasing power in terms of foreign exchange
- To compare markets, the per capita income is converted into foreign terms
- Exchange rate tells how many units of currency it takes to buy one US dollar
- Per capita income does not consider the difference in cost of living from one country to another. Like, the cost of living in the US and India differ, but it assumes that the dollar of income of US and the dollar of income of India has the same purchasing power

5. Human Development Index

- The actual level of development of a country
- How well a country does in terms of social liberties, life expectancy, and literacy rates.
- 3 dimensions

➢ Longevity : Life expectancy at birth

➢ Knowledge : Adult Literacy Rate; Combined primary, secondary and tertiary gross enrollment ratio

Features of Economic Environment

- 1. **Inflation**
- Rise in price measured

against a standard level of purchasing power

- It results when aggregate demand grows faster than aggregate supply
- It affects cost of living, exchange rates, interest rates

Implications of Chronic inflation

- It affects the cost of living as the rising prices makes it more difficult for consumers to buy products unless their income rises at same pace.
- Customers cannot effectively

plan long term investments ,

no incentives to save

Measure of inflation

- US- Consumer Price Index (CPI)
- Europe- Harmonized index of Consumer Prices(HICP)
- India- Wholesale Price Index (WPI)

- HICP includes rural population and excludes occupied housing

Employment

- It is number of workers who want to work but do not have jobs

Unemployment Rate

$$\text{Unemployment Rate} = \frac{\text{\# of Emloyed Workers}}{\text{Total Labor Workforce}}$$

- Results in low economic growth, creates social pressures and provoke political uncertainty

Income Distribution

- Fractions of population that are at various levels of incomes
- **Ginni Coefficient** – assess degree of inequality in distribution of

  income

Income Distribution among wealthy nations

- US has largest inequality gap
- Share of income to top 1% has increased and decreased for the poorest 40%

- Urban vs Rural Income- In china urban income is 7times more than rural income

POVERTY

Poverty: Condition where a person or community is deprived of or lacks the essentials for minimum standard of well being and life.

Poverty as per World Bank:

- Extreme Poverty: living less than $1 per day(PPP)
- Moderate poverty: living less than $2 per day(PPP)

- **Poverty and Economic Environment:**
  - Throughout the world people struggle for basic necessities.
  - In face of extreme poverty market systems may not exist, national infrastructures may not work, criminal behavior may be pervasive and governments may not be able to regulate society or adopt prudent policies.
  - Growth of the economy of business depends on alleviating poverty.

LABOR COST

LABOR COST

- Key element of total cost.
- Companies scan the world to identify the difference between low cost and high cost countries.

PRODUCTIVITY

- Amount of output created per unit input used.
- It is the efficiency with which goods and services are produced.

BALANCE OF PAYMENTS

- Statement of country's trade and financial transactions created by individuals, business and government agencies.
  - CURRENT ACCOUNT
  - CAPITAL ACCOUNT

ECONOMIC SYSTEM

- An economic environment is a mechanism that deals with the production, distribution and consumption of goods and services.
- It is a set of structures and processes that guides the allocation of resources and shapes the conduct of business activities in a country.
- The spectrum of economic analysis is anchored by ideas of: i) Capitalism

  ii) Communism

- CAPITALISM
  - Free market system built on private ownership and control.
  - Owners of capital have inalienable property rights that give them right to earn a profit in return of their effort, investment and risk.
- COMMUNISM
  - Centrally planned system built on state ownership of economic factors of production and control of all economic activity.

TYPES OF ECONOMIC SYSTEM

- MARKET ECONOMY
- COMMAND ECONOMY
- MIXED ECONOMY

MARKET ECONOMY

- A system in which individuals, rather than government make the majority of the economic decisions.
- Gives individual freedom to decide where to work doing what, how to spend or save money and whether to consume now or later.

Private Ownership of resources under Market Economy:

- Individuals make decisions therefore market economy depends on individuals and companies owning and controlling resources rather than government.
- Consumers influence the allocation of resources through their demand for products.

Role of Government Intervention:

- Depends on few government restrictions as possible.
- Believes that less invisible the “hand” becomes due to government intervention , less efficiently the market will run.
- The invisible hand is not infallible, given the needs for some public goods.

COMMAND ECONOMY

- Also known as centrally planned economy.
- Government owns and controls all resources.
- The government commands the authority to decide what goods and services, the quantity in which they are produced and the price at which they are sold.
- Governments owns the means of production which are managed by employees of state.
- Prices do not change much but quality of goods dramatically affected.

Continued..

- Most Products are short in supply.
- Consumers have few alternatives.
- Not much incentive for companies to innovate
- Little profit to invest in upgrades.

ADVANTAGE: State has ability to mobilize unemployed or underemployed resources to generate growth.

MIXED ECONOMY

- Fall in middle of Capitalist and communism.
- System in which economic decisions are largely market driven and ownership is largely private, but the government intervenes in private economic decisions,
- Has elements of – market and central planning economies.
- The government owns key factors of production yet consumers and private producers influence price and quantity.

Linkage between environment and economy can be studied from the following points of consideration

I. Environment in Economic Analysis

- Environmental issues are considered in the production and consumption analysis in economics.
- Green production and green consumption is demand of the modern world.
- In economics tools of fiscal policies are discussed in the environmental context.

Continued.....

- There are three factors of production, natural, physical and human factors. Natural factors are directly connected with the environment.
- Environmental considerations are very important in Micro and Macro economics, agriculture, industrial economics, public finance, regional economic planning etc. Environmental policy becomes an important part of economic policy.

II. ECONOMICS IN ENVIRONMENTAL ANALYSIS

- Environment resources, their allocation and utilization are considered in the context of their economic cost benefit
- There are many environment theories which have developed with the integration of economic theories.

These include

- ✓ environment resource planning,
- ✓ sustainable environment,
- ✓ development environment,
- ✓ input-output model,
- ✓ environment cost analysis,
- ✓ environment policy, environment pricing,
- ✓ environment budgeting, environment
- ✓ fiscal analysis etc.

III. Environmental problems and their solution in Economics

- With the help of input-output analysis, cost benefit analysis, pollution tax and environmental subsidies, economics shows various ways and means to solve the environmental problems.
- Environmental problems are basically man-made and economics has solution for them.

IV. Mutual Dependence:

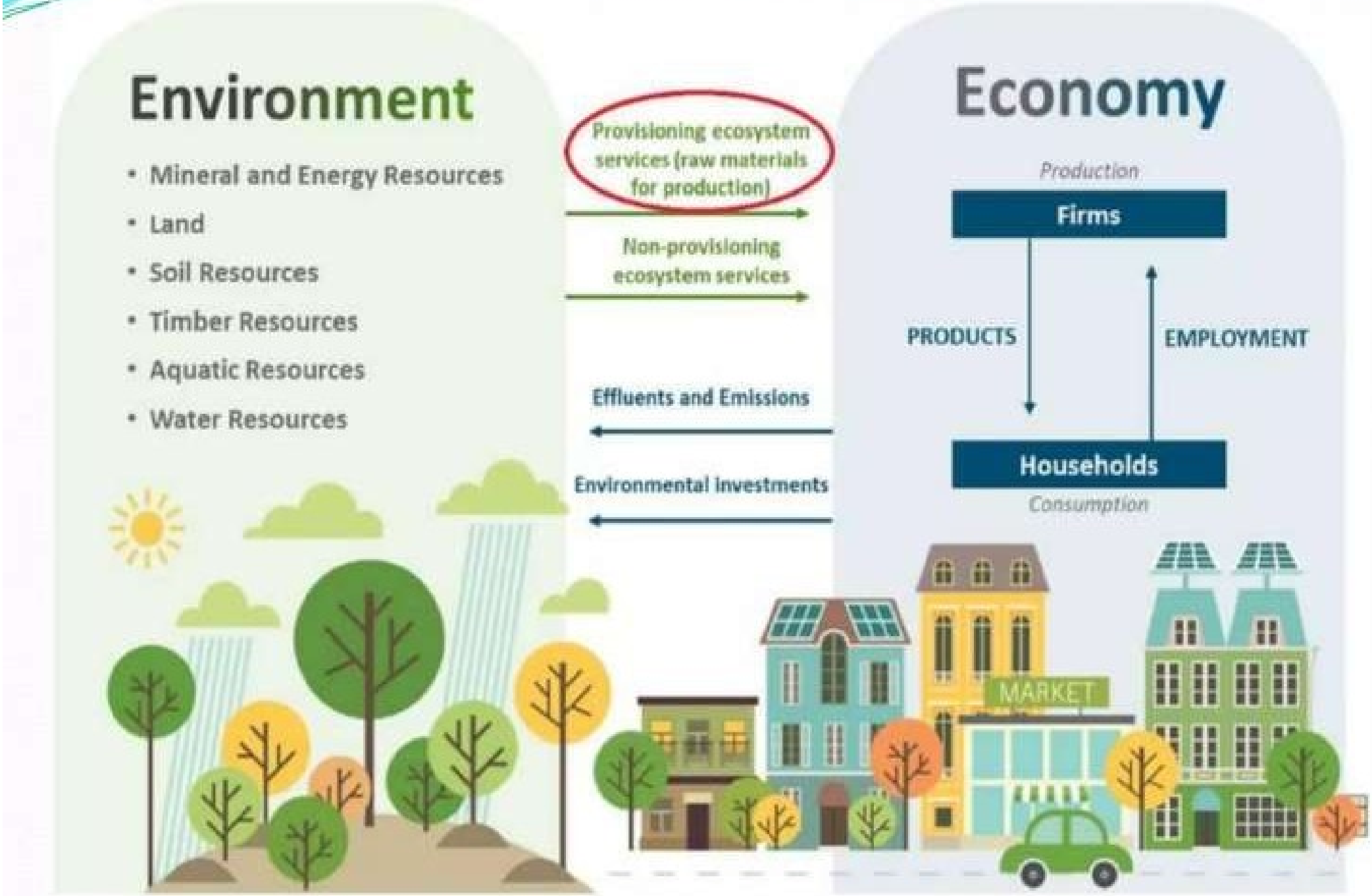
- There are environmental causes for economic problems and economic causes for environment problems.
- There are economic solution for environment problems and environment solution for economic problems.
- In the same way, environment theories are needed for economic theories and economic theories are essential for environment theories.

V. Environment provides resources to the economy

- Environment provides land, water, air, energy resources, coal, oil, forests, minerals and metals and so many other natural resources which are essential for the economic development of the economy.

VI. Environment assimilates the waste and provides utility:

- Natural resources are input to the economic system and natural wastes are recycled.
- For example, trees dispose of their leaves, decompose and are converted into an organic fertilizer for plants.
- Whatever we use up for way of resources, must end up somewhere in that environment system and cannot be disappeared or destroyed


Environment
• Mineral and Energy Resources
• Land
• Soil Resources
• Timber Resources
• Aquatic Resources
• Water Resources
Provisioning ecosystem services (raw materials for production)
Non-provisioning ecosystem services
Effluents and Emissions
Environmental investments
Economy
Production
Firms
PRODUCTS
EMPLOYMENT
Households
Consumption
MARKET

ENVIRONMENTAL IMPLICATIONS OF THE KUZNETS CURVE

INTRODUCTION

- In the 1980s large issues such as ozone layer depletion, global warming and biodiversity loss began to refocus the debate around the impacts of environmental degradation on economic growth. Interest was shifting away from natural resource availability towards the environment as a medium for assimilating wastes
- This led to the emergence of the 'source' to 'sink' concept
- Following the Brundtland Report (1987), the discourse of sustainable development largely embraced economic growth as a way out of poverty, social depravation and also environmental degradation particularly for the developing world.

Why might economic growth benefit the environment?

There are a number of theoretical explanations that suggest the sink side of the environment will be less impacted as incomes rise.

- Environmental quality is often cited as a normal good, if not even a luxury good. In other words, the income elasticity of demand for environmental quality is greater than zero, possibly even greater than one, or as income grows environmental concern rises as well, perhaps even more than proportionally so.

- In addition, rich countries may be better able to meet the higher demands for environmental protection through their institutional environmental capacity.

- It is likely that economic growth increases the possibility that more modern and less pollution intensive man-made capital and technology are introduced. While pollution per unit of output might go down, absolute pollution levels might very well go up as economic growth increases. Therefore the effect of technological change on pollution is in principle ambiguous

- As economic development progresses and income grows, the share of industry will go down as services goes up, thus sectoral changes may favor less-polluting sectors.

- It is also suspected that high-income countries have become cleaner because they have exported their pollution-intensive industry to LDCs, also known as the "pollution haven hypothesis.

- Rising income brings population growth rates down, therefore population pressure on the environment decreases

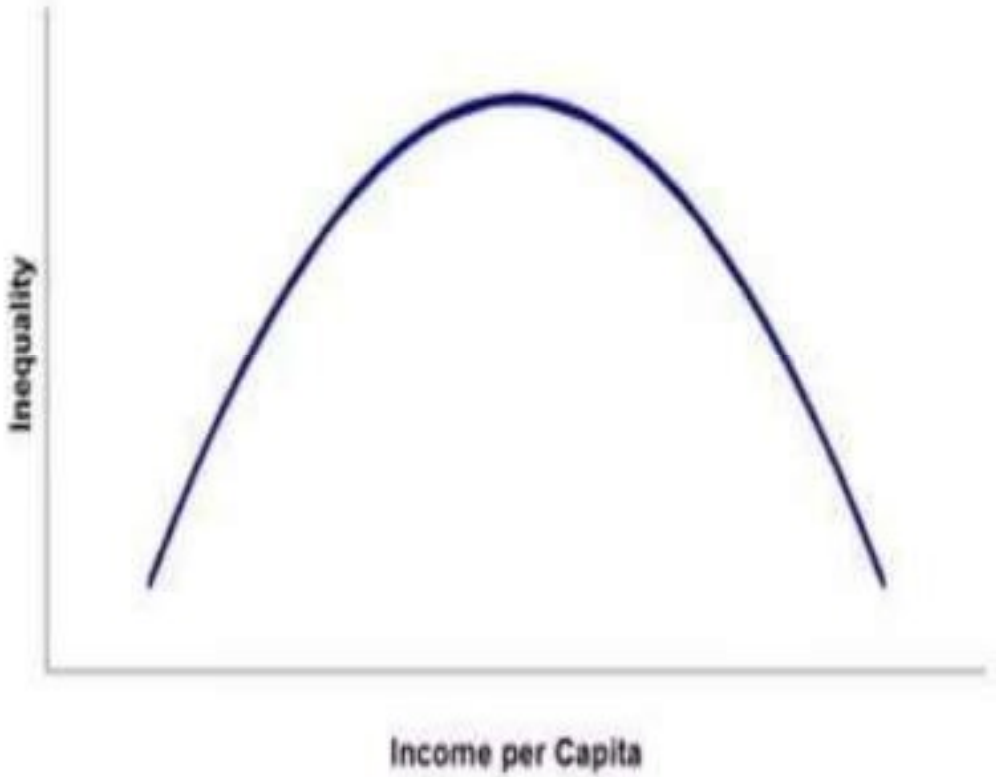
- Thus the relationship between economic growth and the environment came under increased scrutiny.

- In the 1990's the empirical literature on the link between economic growth and environmental pollution literally exploded. Much of this literature sought to test the Environmental Kuznets Curve (EKC) hypothesis.

- This curve is named after Kuznets (1955) who hypothesized that economic inequality increases over time and then after a threshold becomes more equal as per-capita income increases.

Kuznets Curve

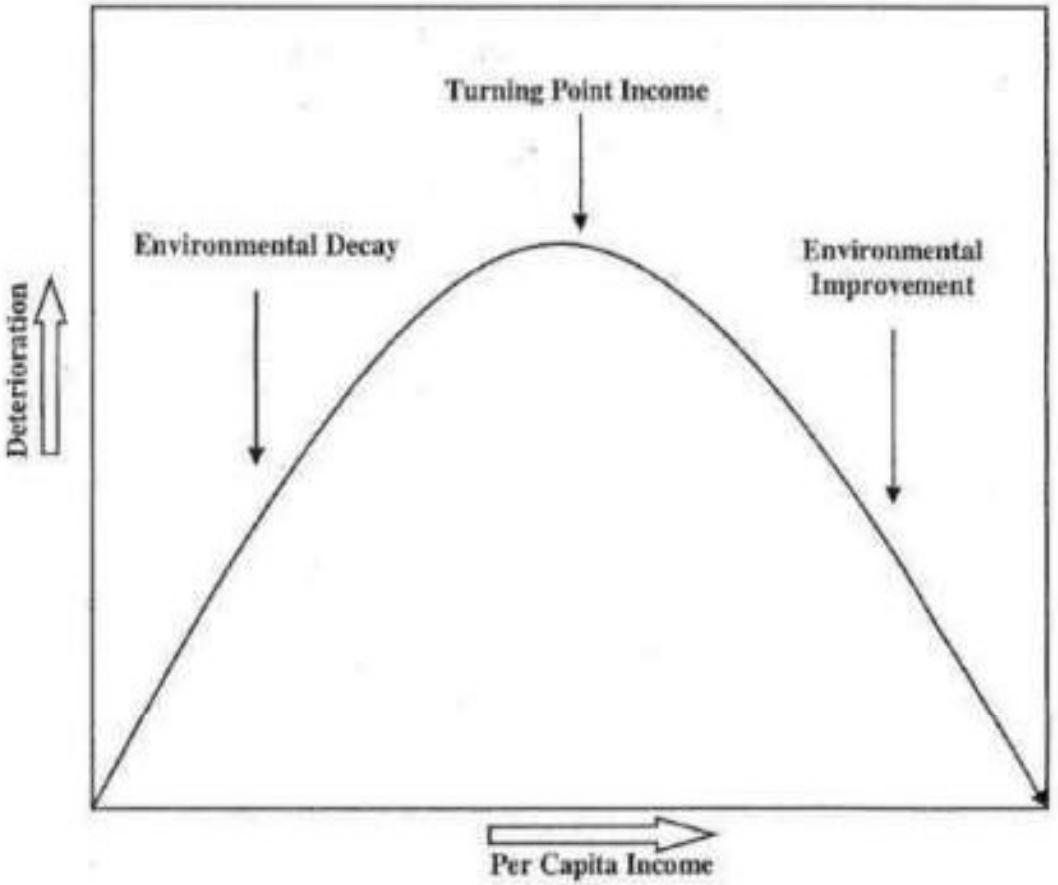
A **Kuznets curve** is the graphical representation of Simon Kuznets' hypothesis that as a country develops, there is a natural cycle of economic inequality driven by market forces which at first increases inequality, and then decreases it after a certain average income is attained.



The Kuznets curve implies that as a nation undergoes industrialization , the centre of the nation's economy will shift to the cities. As capitalism causes a significant rural-urban inequality gap, rural populations are expected to decrease as urban populations increase, due to people migrating to cities in search of income. Inequality is again expected to decrease when a certain level of average income is reached and the processes of industrialization allow for the trickle-down of the benefits from rapid growth, and increase the per capita income. This was Kuznets' belief; that inequality would follow an inverted "U" shape as it rises and then falls again with the increase of income per capita.

The Rise and Fall of the Environmental Kuznets Curve

When the Kuznets curve is applied to environment it is called the environment Kuznets curve. Thus the Environmental Kuznets Curve (EKC) is an adaptation of Simon Kuznets curve.



The Environment Kuznets curve is a hypothesized relationship between various indicators of environment degradation/ deterioration and income per capita.

The EKC again follow growth in per capital income from very low to higher levels, but instead of graphing this against income inequality, the new variable is pollution(deterioration).

When the EKC relation holds, what might be the reason? Here are some possible explanations:

• Environmental quality may be income elastic. As individuals enjoy greater incomes, they demand better environmental quality either through markets or regulatory policies.

•At lower levels of per capita income found in pre-industrial and agrarian economies, one might expect rather pristine environmental conditions relatively unaffected by economic activities

• The EKC relationship suggests that as development and industrialization progress , environmental damage increases due to greater use of natural resources, more emission of pollutants, the operation of less efficient and relatively dirty technologies

•The high priority given to increases in material output, and disregard for or ignorance of the environmental consequences of growth.

•In the post-industrial stage, cleaner technologies and a shift to information and service-based activities combine with a growing ability and willingness to enhance environmental quality.

•Rich countries outsource their polluting industries to less developed countries.

•There is an increasing role of democracy with economic development. Since emissions of many environmental pollutants reflect missing markets, government institutions are necessary to address them. More responsive democracy may be necessary in order to translate individual demand for environmental quality into policies that restrict pollution.

METHODOLOGY

Objective: To explain the environmental implication of Kuznet curve

Procedure:

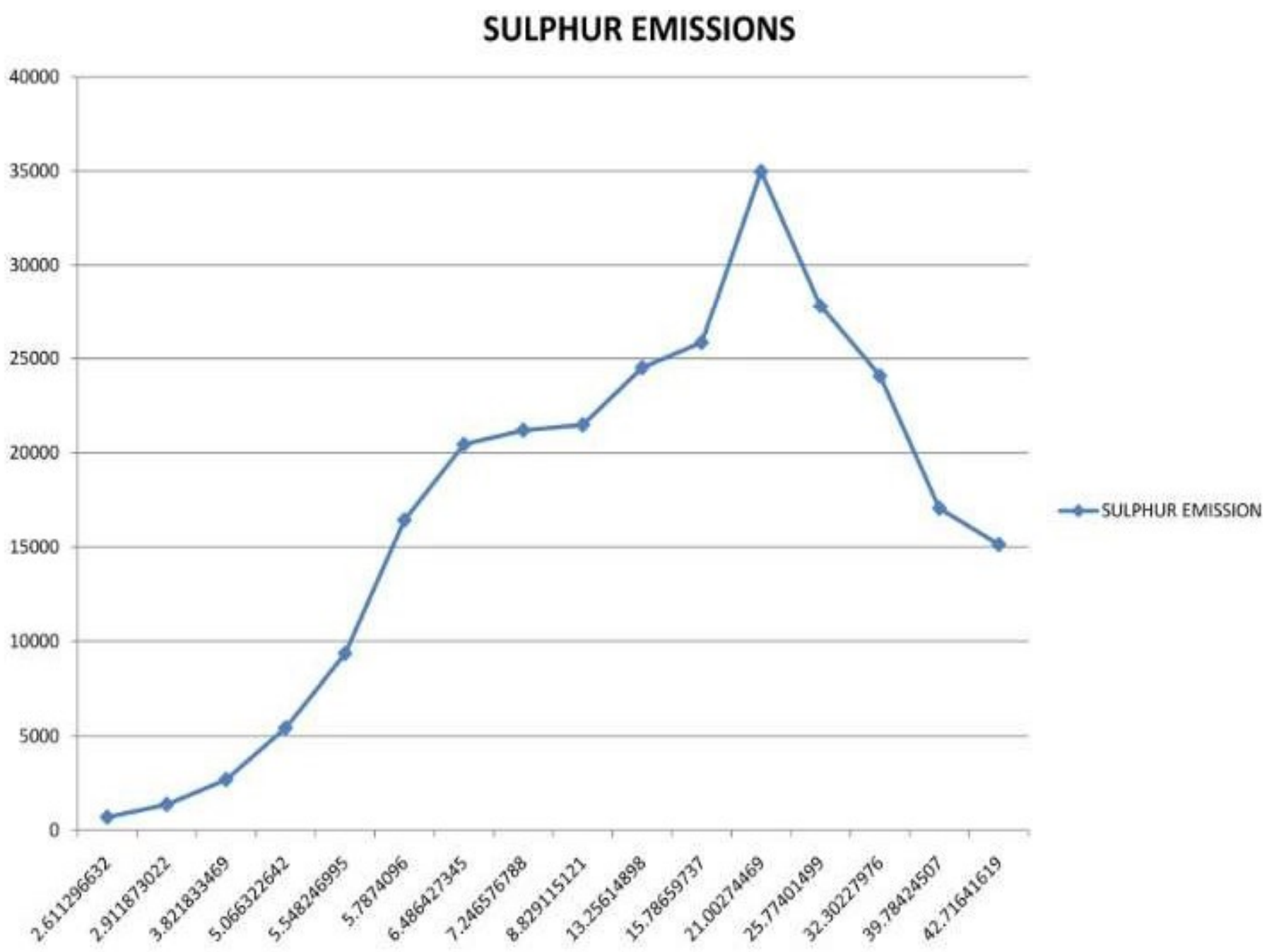
•With regard to USA the two major industrial pollutants are sulphur dioxide and carbon dioxide.

•The data for the same along with the per capita income of USA for the years 1860-2005 (with a 10 year interval) was obtained.

•The data was plotted so as to verify whether these two sets of pollutants follow the relation as explained by the Kuznets Curve.

DATA FOR ANALYSIS

YEARS	sulphur emissions(million tons)	Per capita income, thousand $
1860	707	2.611297
1870	1380	2.911873
1880	2701	3.821833
1890	5443	5.066323
1900	9345	5.548257
1910	16424	5.787410
1920	20436	6.486427
1930	21193	7.246577
1940	21475	8.829115
1950	24513	13.25615
1960	25849	15.78660
1970	34980	21.00274
1980	27809	25.77401
1990	24066	32.30228
2000	17054	39.78425
2005	15131	42.71642


SULPHUR EMISSIONS
40000
35000
30000
25000
20000
15000
10000
5000
0
2.611296632
2.911873022
3.821833469
5.066322642
5.548246995
5.7874096
6.486427345
7.246576788
8.829115121
13.25614898
15.78659737
21.00274469
25.77401499
32.30227976
39.78424507
42.71641619
SULPHUR EMISSION

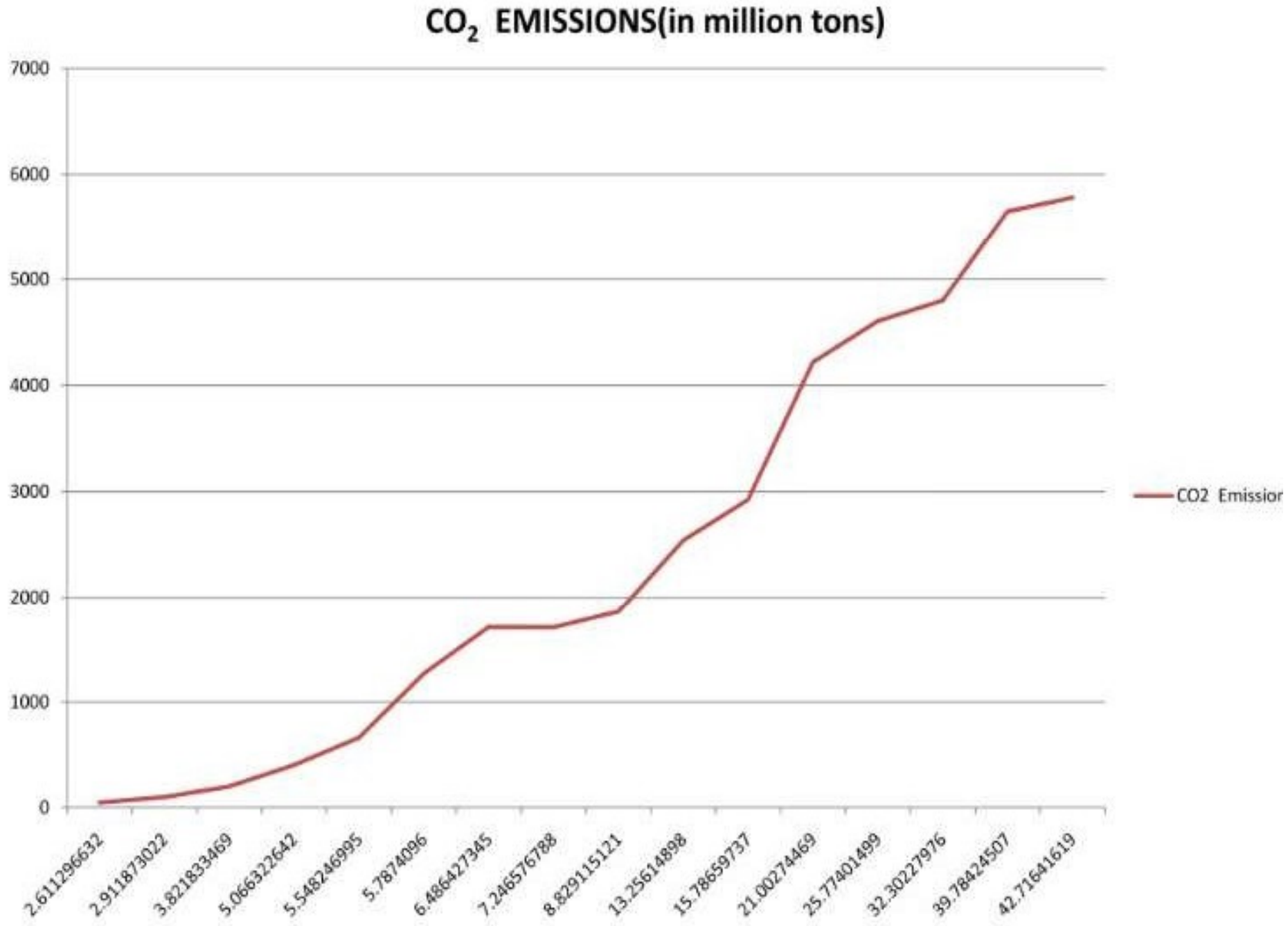
- In the above graph we have tried to obtain the Environmental Kuznets Curve by plotting the per capita income on the X axis and the quantity of sulphur emissions on the y axis starting from the year 1850 to 2005 with a 10 year interval.

- The curve assumes an inverted V-shape with its peak being obtained in the year 1970 when the per capita income was 21.00274.Studies have shown that environmental degradation is worse at levels of income per capita under $1,000. Between $1,000 and $3,000 both the economy and environmental degradation undergo dramatic structural change from rural to urban and from the pursuit of agricultural production to industrial production.

- A second structural transformation begins to take place, he said, as countries surpass a per capita income of $10,000 and begin to shift from energy intensive heavy industry into services and information-intensive industry.

- For the 1960s, toxic intensity grew most quickly in high-income economies. This pattern is sharply reversed during the 1970s and 1980s, when toxic intensity in manufacturing in less developed countries grew most quickly.

YEARS	CO_2 emission(million tons)	Per capita income(thousand $)
1860	47.47	2.611297
1870	98.69	2.911873
1880	198.83	3.821833
1890	402.04	5.066323
1900	663.22	5.548247
1910	1270.15	5.787410
1920	1710.84	6.486427
1930	1708.34	7.246577
1940	1858.02	8.829115
1950	2538.15	13.25615
1960	2921.75	15.78660
1970	4220.54	21.00274
1980	4607.55	25.77401
1990	4801.00	32.30228
2000	5650.38	39.78425
2005	5780.64	42.71642


CO_2 EMISSIONS(in million tons)
7000
6000
5000
4000
3000
2000
1000
0
2.611296632
2.911873022
3.821833469
5.066322642
5.548246995
5.7874096
6.486427345
7.246576788
8.829115121
13.25614898
15.78659737
21.00274469
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32.30227976
39.78424507
42.71641619
CO2 Emissior

- However when we repeated the same exercise for carbon dioxide emissions with regard to the same years we found a different trend, one which was consistently increasing. The reasons for this could be the following:
- Sulphur emissions mainly come from manufacturing production activities. On the other hand, the case is different in carbon emissions. Carbon emissions arise from not only production but also from consumption such as :

1. Automobile use
2. Burning of fossil fuels for the generation of electricity

These are easily externalized even at the global level and thus not subject to regulation and that is why carbon emissions, which don't follow the EK curve pattern, continue to rise.

CONCLUSION

- The EKC has been criticized on the grounds that it is based upon the assumption that there is no feedback from environmental damage to economic production as income is assumed to be an exogenous variable. Environmental damage does not reduce economic activity sufficiently to stop the growth process. In other words, there is an assumption that the economy is sustainable.
- Thus though we have used the Environmental Kuznets Curve to depict the outsourcing of polluting industries it may not be the most reliable method.

The Sustainability debate

Proponents of sustainable development maintain that there are 6 principles of sustainability, these include:

1. A Circular Economy

The goal of the circular economy is to lessen the burden on finite resources by reducing the amount of trash thrown away. We can save a lot of money and resources by avoiding and reducing waste throughout a product's lifespan and recovering useful components for reuse.

2. Conserving Energy (Energy Conservation)

LEDs and other technologies like intelligent controls and cutting-edge optics allow for more efficient and effective lighting while reducing waste and resource use. This involves minimizing waste and maximizing efficiency in manufacturing to guarantee there is no overage.

The Sustainability debate

3. Alternatives to Nonrenewable Resources
We choose materials that will hold up better in salty, coastal conditions without sacrificing performance.

4. Continuous Efforts in the Areas of Study and Development
The key is to keep improving on past success to provide cutting-edge tech, dependable support, and affordable rates to all of our customers.

5. Environmental Product Reporting (EPD)
As a result, we may learn more about the materials and components utilized in a product's production and the effects those materials and components have on the Environment across their entire life cycles. Furthermore, they discuss the product's valuable and technological characteristics and eventual demise.

The Sustainability debate

6. Taking Corporate Responsibility for Social Issues
Nowadays, companies take an active role in social responsibility. And while some people argue that it is not the place of private business to dictate the cultural mores of the time, proponents of sustainable development argue that this aspect greatly influences the public's impression of a corporation.

•Change occurs when governments, businesses, and citizens pool their resources and dedication to achieve a common goal.

•When this happens, people can lift themselves and their families out of poverty, children are shielded from preventable diseases, girls choose education over marriage, and so much more. Here are arguments for sustainable development;

The Sustainability debate

Argument 1. Increasing Numbers of Infants Are Making It to Adulthood

•Child fatalities fell by approximately 50% from 2000. Millions of youngsters not previously protected from avoidable illnesses received immunizations and health services because of a global effort. We must continue our efforts until every kid has access to enough food, medical care, clean water, and education.

Argument 2. By Working Together, We Can Eradicate Poverty

•Proponents of sustainable development argue that ten percent of people worldwide now live in absolute poverty. Between 1990 and 2015, the global population in extreme poverty fell from 36% to 10%

Argument 3. Almost Nine Out of Ten Individuals Today Have Access to Modern Energy

The Sustainability debate

Argument 3. Almost Nine Out of Ten Individuals Today Have Access to Modern Energy

Most of the world's population now has access to electricity, allowing them to do things like study late at night, cook, and operate enterprises. While we've made great strides, there's still much more to be done to help the 840 million people who still don't have access to electricity and the over 3 billion who use outdated, polluting, and often dangerous cooking methods.

Energy

- It is a ability to do work or to produce heat
- Normally heat could be derived by burning a fuel—i.e. a substance that contains internal energy which upon burning generates heat, or through other means—such as by capturing the sun's rays, or from the rocks below the earth's surface (IEA 2004)
- Similarly, the ability to do work may represent the capability (or potential) of doing work (known as potential energy as in stored water in a dam) or its manifestation in terms of conversion to motive power (known as kinetic energy as in the case of wind or tidal waves)

Contd...

- Energy can be captured and harnessed from very diverse sources that can be found in various physical states, and with varying degrees of ease or difficulty of capturing their potential energies
- Initially the mankind relied on solar energy and the energy of flowing water or air
- With the discovery of the fire-making process, the use of biomass began. The use of coal and subsequently oil and natural gas began quite recently—a few hundred years ago

Contd...

- According to the physical sciences, two basic laws of thermodynamics govern energy flows

✓ The first law of thermodynamics is a statement of material balance—a mass or energy can neither be created nor destroyed—it can only be transformed. This indicates the overall balance of energy at all times

✓The second law of thermodynamics on the other hand introduces the concept of quality of energy. It suggests that any conversion involves generation of low grade energy that cannot be used for useful work and this cannot be eliminated altogether. This imposes physical restriction on the use of energy

Alternative Classifications of Energy

1. Primary and Secondary Forms of Energy
2. Renewable and Non-Renewable Forms of Energy
3. Commercial and Non-Commercial Energies
4. Conventional and Non-Conventional Energies

- Based on the above classification, it is possible to group all forms of energy in two basic dimensions: Renewability as one dimension and Conventionality as the other

Primary and Secondary Forms of Energy

- Primary energy is used to designate an energy source that is extracted from a stock of natural resources or captured from a flow of resources and that has not undergone any transformation or conversion other than separation and cleaning (IEA 2004)
- Examples include coal, crude oil, natural gas, solar power, nuclear power, etc.
- Secondary energy on the other hand refers to any energy that is obtained from a primary energy source employing a transformation or conversion process
- Thus oil products or electricity are secondary energies as these require refining or electric generators to produce them
- Both electricity and heat can be obtained as primary and secondary energies

Renewable and Non-Renewable Forms of Energy

- Non-renewable source of energy is one where the primary energy comes from a finite stock of resources.
- Drawing down one unit of the stock leaves lesser units for future consumption in this case.
- For example, coal or crude oil comes from a finite physical stock that was formed under the earth's crust in the geological past and hence these are non-renewable energies
- On the other hand, if any primary energy is obtained from a constantly available flow of energy, the energy is known as renewable energy. Solar energy, wind, and the like are renewable energies

Commercial and Non-Commercial Energies

- Commercial energies are those that are traded wholly or almost entirely in the market place and therefore would command a market price. Examples include coal, oil, gas and electricity.
- Non-commercial energies are those which do not pass through the market place and accordingly, do not have a market price. Common examples include energies collected by people for their own use
- But when a non-commercial energy enters the market, by the above definition, the fuel becomes a commercial form of energy.
- The boundary could change over time and depending on the location. For example, earlier fuel-wood was just collected and not sold in the market. It was hence a non-commercial form of energy.

- Now in many urban (and even in rural) areas, fuel-wood is sold in the market and hence it has become a commercial energy. At other places, it is still collected and hence a noncommercial form of energy. This creates overlaps in coverage
- Another term which is commonly used is Modern and Traditional energies
- Modern energies are those which are obtained from some extraction and/or transformation processes and require modern technologies to use them.
- Traditional energies are those which are obtained using traditional simple methods and can be used without modern gadgets.
- Often modern fuels are commercial energies and traditional energies are non-commercial. But this definition does not prevent traditional energies to be commercial either
- Thus if a traditional energy is sold in the market it can still remain traditional

Conventional and Non-Conventional Energies

- This classification is based on the technologies used to capture or harness energy sources.
- Conventional energies are those which are obtained through commonly used technologies
- Non-conventional energies are those obtained using new and novel technologies or sources
- Once again the definition is quite ambiguous as conventions are subject to change over time, allowing non-conventional forms of energies to become quite conventional at a different point in time

Energy Classifications

Conventionality	Renewability	
	Renewable	Non-renewable
Commercial	Large scale hydro Geothermal Nuclear	Fossil fuels Other nuclear
Traditional /non-commercial	Animal residues Crop residues Windmills and watermills Fuelwood (sustainable)	Unsustainable fuelwood
New and novel	Solar Mini and micro hydro Tidal and wave Ocean thermal	Oil from oil sands oil from coal or gas

Source Codoni et al. (1985) and Siddayao (1986)

Energy Economics: An Introduction

- Energy issues have been analysed from an economic perspective for more than a century now

BUT

- Energy economics did not develop as a specialised branch until the first oil shock in the 1970s (Edwards 2003).
- The dramatic increase in oil prices in the 1973–1974 highlighted the importance of energy in economic development of countries.
- Researchers, academics and policymakers have taken a keen interest in energy studies and today energy economics has emerged as a recognised branch on its own.

Energy Economics: In 80's, 90's & Now

- Further the scope of the work expanded in the 1980s
- Environmental concerns of energy use and economic development became a major concern and the environmental dimension dominated the policy debate
- This brought a major shift in the focus of energy studies as well- the issue of local, regional and global environmental effects of energy use became an integral part of the analysis
- In the 1990s, liberalisation of energy markets and restructuring swept through the entire world although climate change and other global and local environmental issues also continued

Contd...

- These changes brought new issues and challenges to the limelight and by the end of the decade, it became evident that unless the fundamental design is not well thought through, reforms cannot succeed

- In recent years, the focus has shifted to high oil prices, energy scarcity and the debate over state intervention as opposed to market-led energy supply

- This swing of the pendulum in the policy debate is attributed to the concerns about security of supply in a carbon-constrained world

Energy Economics

- Energy economics or more precisely the economics of energy is a branch of applied economics where economic principles and tools are applied to "ask the right questions" and to analyze them logically and systematically to develop a well-informed understanding of the issues

- Energy economics studies energy resources and energy commodities, and includes:

  ✓ forces motivating firms and consumers to supply, convert, transport, use energy resources, and to dispose of residuals; market structures and regulatory structures; distributional and environmental consequences; economically efficient use

Complexity in Energy Sector

➢The energy sector is complex because of a number of factors:

- The constituent industries tend to be highly technical in nature, requiring some understanding of the underlying processes and techniques for a good grasp of the economic issues
- Energy being an ingredient for any economic activity, its availability or lack of it affects the society and consequently, there are greater societal concerns and influences affecting the sector
- The sector is influenced by interactions at different levels (international, regional, national and even local), most of which go beyond the subject of one discipline
- Analyses of energy problems have attracted inter-disciplinary interests and researchers from various fields

Key Role Of Energy in Economic Activities

- Economy arises because of the mutual interdependence between economic activities and energy
- These interrelations influence
  - ✓the demand for energy, possibilities of substitution within the energy and with other resources (capital, land, labour and material),
  - ✓supply of energy and other goods and services, investment decisions, and
  - ✓the macro-economic variables of a country (economic output, balance of payment situations, foreign trade, inflation, interest rate, etc.)

Contd...

- Also, the national level institutions (including the rules and organisations like government, judiciary, etc.) both influence and get influenced by these interactions
- The energy sector uses inputs from various other sectors (industry, transport, households, etc.) and is also a key input for most of the sectors

Energy Data

- Information/data is crucial for any decision-making: be it development planning decisions or business decisions or decisions by individual consumers
- Reliable and quality information facilitates decision-making and improves the decision-making process
- Any decision-making process requires analysis of the past and present status of the sector (or sub-sector or specific area of concern) and a vision about the future
- This implies that a large amount of both historical and projected data would be required related to the specific components and subsystems of the energy sector

- The information/data requirement would vary by stakeholders, broadly the common requirement would included:

1. Energy use by various economic activities;
2. Energy production, transformation and delivery to various users,
3. Technical and operating statistics of the plants and installations;
4. Financial and cost information, and
5. Macro-economic and other social information.

Data availability, Data Collection and Reporting

- At the national level, some countries produce good information
- In Asia, Nepal, Thailand, Sri Lanka and Philippines have reliable time series data on traditional energy data
- Most other countries have had several studies or surveys on TEs but do not have a consistent time series data
- At the international level, United Nations, Food and Agricultural Organisation, International Energy Agency (IEA) and World Bank are active in data collection and reporting

- In late 1990s, traditional energies came to focus once again in the debate over sustainable energy development
- The workshop on Biomass energy organized by IEA in 1997 attempted to understand the role, level and sustainability of biomass use for energy purposes in non-OECD countries
- IEA has since started to play an important role in collecting and reporting data on Tes
- At the national level, generally data on consumption of TEs is available from special purpose surveys. These surveys can be specifically for TEs or as part of overall energy survey

- The scope and coverage of surveys to be conducted depends on the objectives of the survey in question
- To assess the level and pattern of TE consumption, a large-scale extensive survey at the national/regional level would be required
- On the other hand, rural level surveys would be required if the objective is to assess the possibility of improvements in the existing use-patterns and introduction of new technologies

❑The information/data required may be categorized as follows (Codoni et al. 1985):

➢**Energy Pricing:**

- Despite the liberalization of energy markets, energy pricing continues to be a very sensitive and contentious issue because of social and political implications.

- Regulators and price-setting agencies require considerable information to make correct pricing decisions. This includes: consumption of fuels by various consumers, consumption pattern by income groups, rural–urban divide in consumption and supply, cost of supply to various consumers, impact of price revision on consumers, etc.

➢Energy investment:

- Energy investment decisions have high visibility because of their size. Investment decisions require an understanding of the evolution of demand, pricing policies, business environment, viability of alternative options, and various types of impacts. Historical and forecast data are required for such exercises.

➢Energy research and development (R&D):

- Decisions on R&D require information on resources of various kinds of fuels, cost of production and conversion, evolution of demand for various kinds of fuels, costs and benefits of investment in R&D activities, etc.

➢System management:

- Decisions on energy system management would normally be taken by the operators themselves but quite often there would be some regulatory or governmental supervision/involvement
- The requirement is significantly high in the case of electricity where supply and demand balancing has to be ensured every moment
- The information required includes supply and demand positions, system availability, technical constraints, etc.

➢Contingency plan:

- Any system should remain prepared to deal with a number of contingencies

- Complete or partial system failure, supply failure due to technical or other problems, erratic change in demand, etc.
- Preparation of a contingency plan would require information on geography of energy supply, distribution and consumption, technical features of the system, knowledge of social and economic impacts of energy disruption, etc.

➢ **Long-term planning:**

- This involves developing a view of the possible future evolution of energy demand and the possibilities of fulfilling that demand in various ways

- This requires a proper understanding of the followings:
  - ✓current consumption activities and consumption pattern,
  - ✓possible changes in the activities in terms of efficiency and structure,
  - ✓possible supply alternatives, possible technological changes, etc.

Common Energy Data Issues

- A number of conceptual, technical problems and data-related issues are confronted while dealing with energy data *(Codoni et al. 1985; Siddayao 1986; IEA 1998; Ailawadi and Bhattacharyya 2002)*

➢ **Data availability:**

- Often multiple agencies collect and publish data. Collection and reporting involves some time lag and delayed publication of information is quite common
- Delays reduce usefulness of the information and its value
- Data on energy use is often sketchy and inadequate. Even in cases where a network is used for supply, reliable information on consumer category-wise usage is not available

- Manual systems for recording and storing information coupled with managerial incompetence are responsible for such poor state of affairs

➢ **Data quality:**

- There is doubt about the quality of information whenever data is available. This is because in absence correct sales and consumption information, estimates are used and their basis is often questionable
- Besides, consistency problems also arise in data and arithmetic errors, internal inconsistency, logical errors, etc. are not uncommon. For example, in the case of natural gas, production may be reported on gross (i.e. including gas vented, flared and re-injected) or net basis

- Countries use different conventions about energy classifications and consumer categorization. The boundary problem arises due to:

1. Exclusion of or inclusion of traditional fuels;
2. Different terminologies used for the same product
3. Different user sectors identified for different data (e.g. electricity end use sectors may be different from that for petroleum products);
4. Accounting for differences in energy efficiencies, efficiencies of energy delivering equipment, etc.

➢ **Common measurement unit:**

- Aggregating energy sources of different characteristics is a difficulty faced in energy data. The problem is how to aggregate energy forms of different qualities in a way that will allow appropriate cross country comparisons

- In order to present the variety of units on a comparable basis, a common denominator for all fuels is required.
- Traditionally, the common denominator is their energy or heat content, expressed in Joules, Btu or kWh. Units like tons of coal or oil, or barrels equivalent are derivatives of the heat content

➢ **Conversion factors:**

- This is related to common measurement unit
- Once a choice is made about the common denominator, the next question comes is how precise does the conversion factor need to be and how much will the overall picture change if one factor is used rather than the other
- The quality of certain products such as coal varies significantly from one country to another and also from one extraction site to another

- This necessitates a specific factor for each country and often for each time period as the domination of different extraction sites vary from year to year
- For other products, the variation may not be significant and a common factor may be used

To resolve these issues, a number of initiatives have been taken:

✓For oil statistics, the Joint Oil Data Initiative (JODI) has created a platform for interaction of various stakeholders

✓Similarly, the UN Statistical Commission and UN Statistics Division are working on the challenges facing the energy statistics

✓ The UN organisations are working towards revising the older manuals and recommendations for international energy statistics

NON RENEWABLE ENERGY RESOURCES

- Non-renewable energy is energy which is taken from the sources that are available on the earth in limited quantity and will vanish fifty-sixty years from now.
- Non-renewable sources are not environmental friendly and can have serious affect on our health.
- They are called non-renewable because they cannot be re-generated within a short span of time. Non-renewable sources exist in the form of fossil fuels, natural gas, oil and coal.

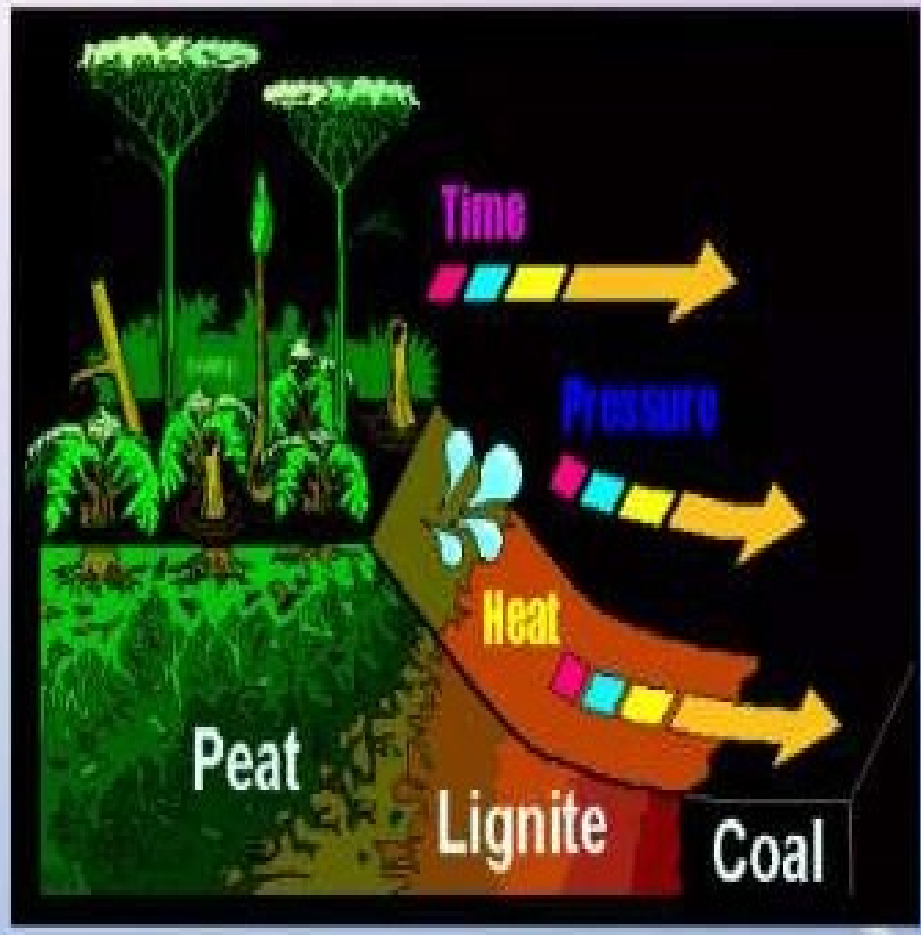
FOSSIL FUEL ENERGY

- Coal, petroleum, and natural gas are called fossil fuel as these are formed by the decomposition of the remains of dead plants and animals buried under the earth for a long time.

HOW IS COAL FORMED?

- Coal is formed by carbon, hydrogen, oxygen, nitrogen and varying amounts of sulphur. The dead plants from the swamps are piled up with sand and mud on top. Without water the carbon increases and forms a hard black substance called coal.

- Coal is used as a fossil fuel to produce electricity and heat in something such as a train.

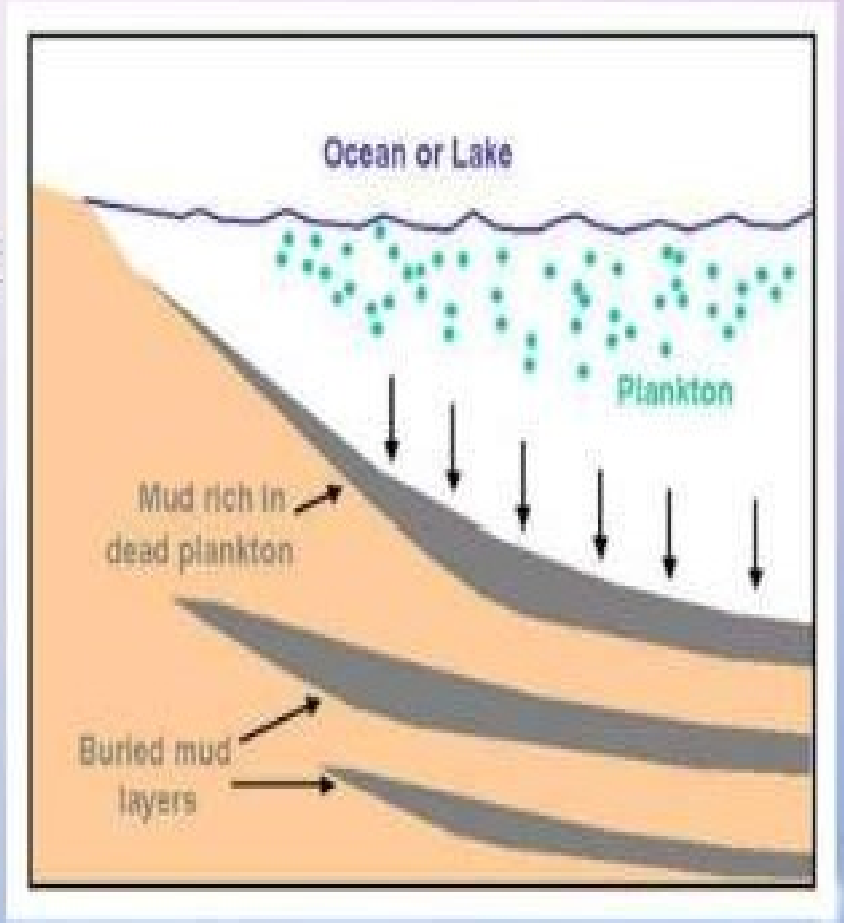


IMPACT OF COAL MINING ON ENVIRONMENT

- Impact of mining on Air
- Co2 emission
- Ozone depletion
- Global warming and climate change
- Mine fires
- Impact on water
- Impact on land
- Mining waste

HOW IS OIL FORMED?

- Oil was formed from plants called plankton. When the plankton dies, it sinks in the bottom of the sea and is buried under layers of sand and mud. When these layers are mixed it turns into a hard rock, but when bacteria ate the plankton, it turned into ooze, which is now oil.
- Oils are used for ,Fuel for lamps , fertilizers, pens, car gas, heating oil for home, planes, ships, factories, food



Advantages;

- Widely and easily distributed all over world
- Easy to store and transport
- Cleaner and easier to burn than coal
- Reliable electricity

Disadvantages;

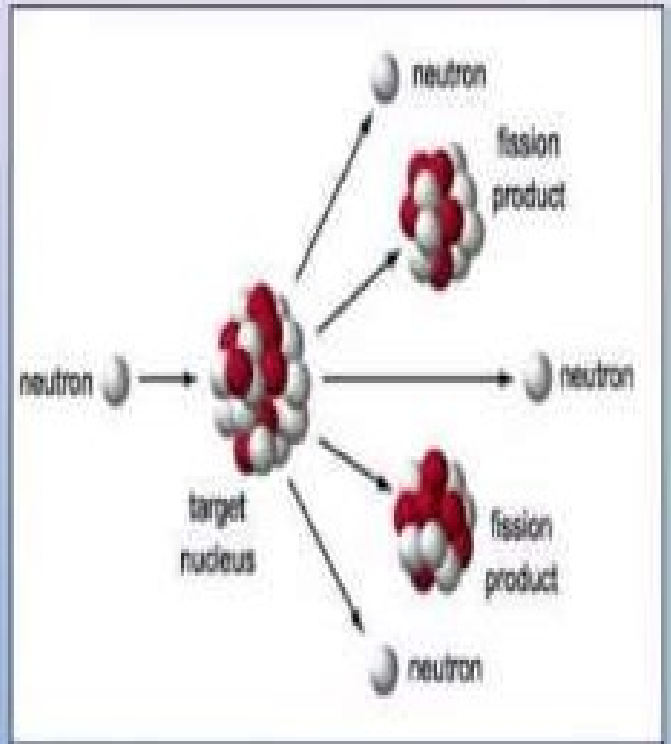
- Growing demand
- Non-renewable and fast depleting(used up fast)
- Burning produces carbon dioxide which is major cause for global warming\leaves harmful products when combusting
- Increasing prices

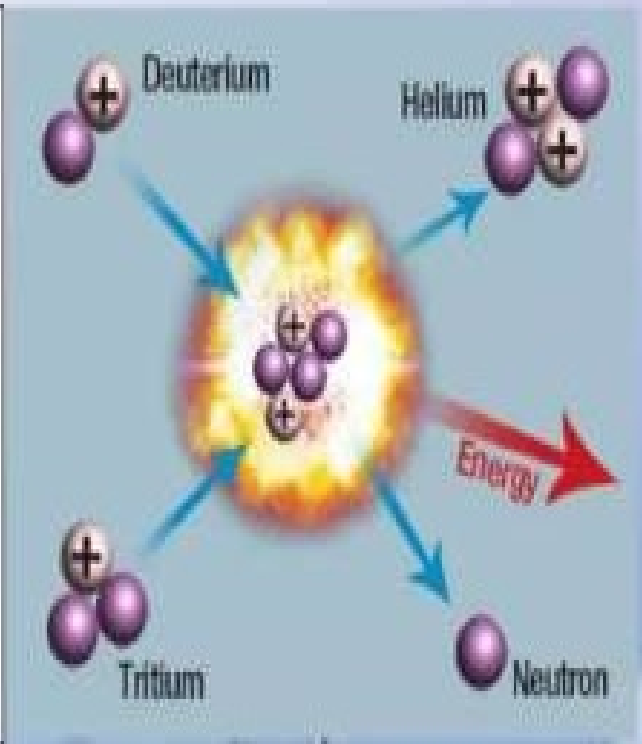
NUCLEAR ENERGY

- *Nuclear energy is a powerful source of energy, generated during a nuclear reaction, by change in the nucleus of an atom.*
- *Two ways to obtain nuclear energy:*

  1. Nuclear fission

  2. Nuclear fusion





ADVANTAGES OF NUCLEAR ENERGY

- Nuclear plants bring job and prosperity to country
- Provides the world with the most of its electricity
- Not many nuclear have happened; natural disasters cause more damages
- Canada has easy access to uranium
- Its good for the economy
- Lot of energy is produced from a small amount of uranium
- Do not emit co2
- Generating electricity from nuclear energy cause little pollution

DISADVANTAGES OF NUCLEAR ENERGY

- Disposing of nuclear waste is very difficult and needs to be done after a lot planning by the experts
- The radioactive waste takes years to be no longer hazardous
- Waste must be stored very carefully for a long time
- Storing is a huge problem. Waste is very dangerous. It is radioactive
- Nuclear power plants are very expensive to build
- Uranium is not renewable and can lead to environmental problems through mining and processing

NUCLEAR FISSION

- ***Nuclear fission reaction,*** *the nucleus of a heavy radioactive element like uranium, plutonium or thorium splits up into smaller nuclei, when bombarded by low energy neutrons. A huge amount of heat is generated in this process, which is used in nuclear power plants to generate electricity.*

NUCLEAR FUSION

- ***Nuclear fusion reaction*** *involves the combination or fusion of two light elements to form a heavier element and release uncontrollable energy. Thus it cannot be used to generate electricity, unlike fission reaction.*
- *The heat and light that we get from sun, is all due to the continuous reactions going on inside it. We can now imagine how much energy would be released in the nuclear fusion reaction, that it is the source of sun's energy*

- The supply of energy is far less than its demands can effect the whole mankind to run towards the development or daily purposes that crisis is called energy crisis

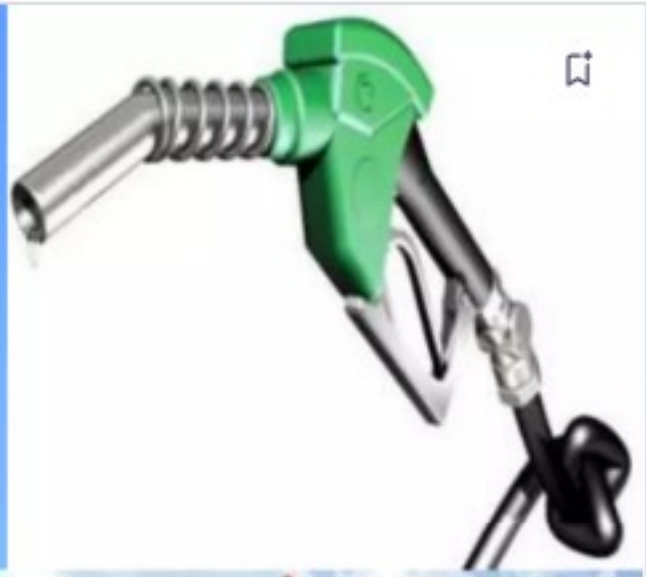
DEMANDS IN ENERGY INCREASING

LACK OF ENERGY

CAUSES

(a) Oil Shortage:

Reserves of mineral oil in India is only 0.3% of world's known oil reserves. Oil shortage adversely effect the transport sector in the economy. Again rising oil prices has led to rising general prices in India.



(b) Coal shortage:

Coal reserves are quantitatively and qualitatively poor. Coal shortages adversely affects generation of electricity, therefore, restricts the economic development.

(c) Power shortage:

A severe shortage exists in generation and distribution of electric power in India. Power shortage affects

- industrial as well as agricultural production seriously.

(d) Population Growth:

The increased population desires more products to use, results in using more energy to make those products in order to provide more infrastructures.

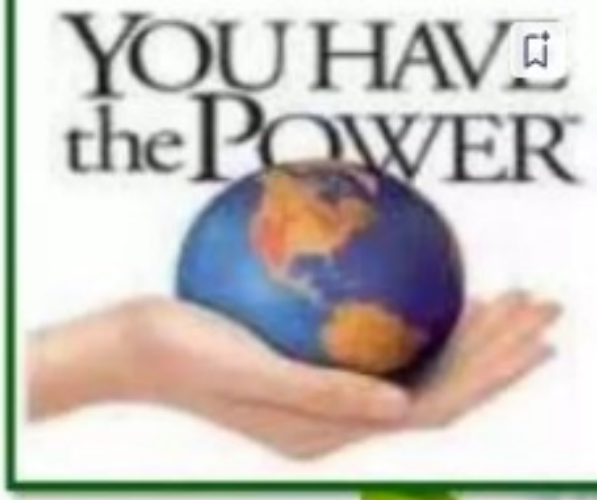
(e)Natural Disasters

(f)Attacks By Terrorists

Efforts to be made by the Govt.

- Thus, efforts must be made, and structures put in place, by government and non governmental organizations for the development of necessary policies and legal frame works well as programs that promote the adoption of renewable energy for sustainable development.

WHAT WE CAN DO ?



- **RECYCLE -** compositing waste materials into new products to prevent waste of potentially useful materials.
- Turn off all electronic devices that are not in use. Not only turn them off but try to remember to unplug them. You will be surprised how much you will save with this simple step!
- Replace old light bulbs with energy saving fluorescent bulbs. They may cost more, but will save you much more in the long run.

At Home

- We should not keep lights unnecessarily switched on.
- Reduce the energy your appliances consume by analyzing star ratings.
- Improve your water heating efficiency to reduce energy costs.

At Public Places

- Switch of the fans and lights in the places like bus terminal and railway stations when not necessary.
- Switch off the street lights.
- Big Hoardings, lightened up for the whole evening and nights are other wastage of power which can be and should be avoided

REDUCING ENERGY CONSUMPTION

(at local level)

- Look for the "Energy Star" logo.
- Use smaller kitchen appliances.
- Use lids on pots and pans to reduce cooking times.
- Switch to compact fluorescent light bulbs.
- Remember that it pays to invest in energy efficiency.
- Keep curtains and blinds closed at night.
- Install more attic insulation.
- If your basement is unheated.
- Maintain your central air conditioner by cleaning the outside compressor.
- During late afternoon and early evening, turn off unnecessary lights.
- If your home can't accommodate central air conditioning, try a whole-house attic fan.
- During the winter, remove window air conditioners.
- Reflective window film.

Hotelling's theory of Optimum Extraction of Non-renewable Resources

- Production by a firm is different from mineral extraction.
- In a mine, as more extraction takes place, the stock of the reserves starts decreasing.
- This reduces the resource availability for future extraction.
- So there is an opportunity cost of extraction.
- Therefore the mine owner has to decide what should be the optimum level of depletion so as to earn profits now as well as in the future.
- Conservation of the mineral depends on the expected future price, and the rate of discount.

- Micro level: a mine-owner has to decide how much of the mineral to extract in each time period.
- With each year's extraction, the reserves of the mine will be reduced, and eventually the mineral will be exhausted.
- Too much of extraction in the present time period reduces the amount of the mineral for future extraction,
- But conserving the mineral for future extraction will reduce the profits of the present.

Hotelling's Theory of Optimum depletion of exhaustible resources (1931)

Hotelling tries to discover the conditions under which exhaustive resources can be extracted optimally over time, under perfect competition.

Assumptions:

- Micro analysis of an exhaustible resource (e.g. coal).
- Perfect competition in the product market, the price (p) of coal is constant.
- Price is known to the mine owner.
- Constant returns to scale. Extraction costs do not rise but remain constant, even as the mineral gets exhausted.

- No change in technology or improvements in mining.
- So MC remains constant. AC = MC
- Perfect foresight regarding future costs, demand and prices, no uncertainty.
- Downward sloping demand curve for the mineral.
- Mine owner is aware of the stock reserves of the non-renewable resource.
- Constant extraction costs, as mineral gets depleted, extraction costs do not rise.

User Cost or Hotelling Rent :

- User Cost: the *opportunity cost* of postponing extraction of a non-renewable resource.
- If extracted now, present profits are earned, but mineral is depleted.
- But if extraction is postponed, then profits can be earned in the future.
- *User Cost* is the present value of the marginal profit from selling the resource in the future.
- The amount he expected in future for conserving the resource, rather than extracting it now.

Augmented User Cost (AMC) :

- *AMC* of the mine owner
- The opportunity cost of not depleting the resource is added to the marginal cost.
- The miner's decision to extract the resource depends on his AMC, and not MC.

$$AMC = MC + UC$$

Miner has to decide how much to extract in the present period, and how much to conserve for the future.

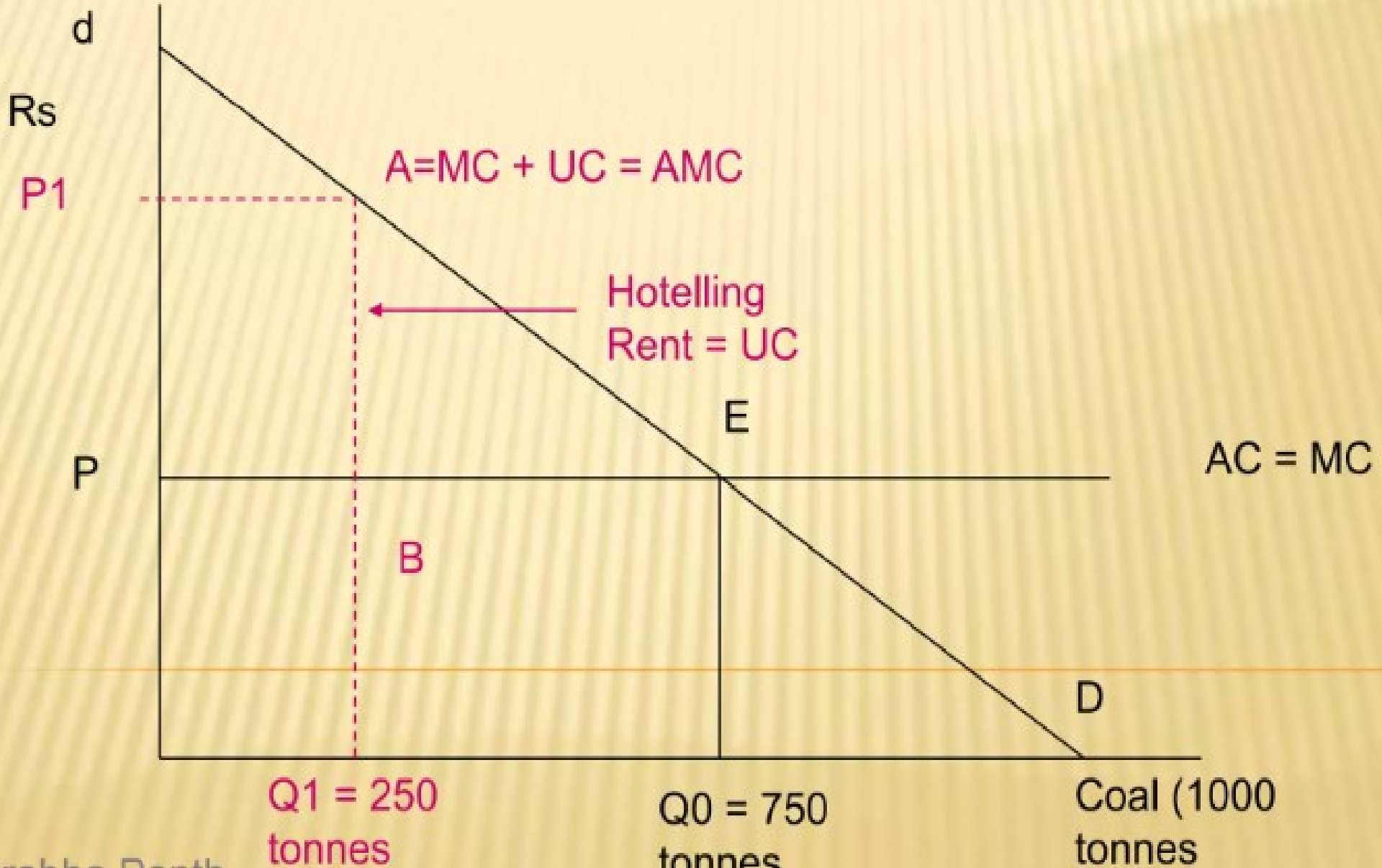
Conditions for Optimal depletion of the exhaustible resource:

- In PC, equilibrium is when P = MC
- In the case of NRR,

$$P = AMC = MC + UC$$

- Also, postponing extraction for the future involves time preference.
- Therefore future price should exceed present price of extraction, to compensate for loss of present earnings due to conservation.

Diagram of Hotelling Model:



When to postpone extraction:

- Extraction leads to exhaustion of the resource, if MC = P rule is followed in perfect competition.
- Mine owner expects resource price may rise in future due to resource scarcity,
- The minimum amount of expected increase in price in future = (P1 – P0) = (UC).
- In the diagram P1 > P0, the difference is UC, i.e. P1 = P0+ UC.
- If future P1> P0, then the mine owner will be prepared to postpone resource extraction.

Time Preference or NPV:

- Postponing extraction, means postponing earning of profits,
- Waiting for the future earnings involves loss of interest on present earnings. ,
- Therefore the future expected profit has to be discounted by the rate of interest.
- Miner compares present earnings at the given price, with the discounted earnings overtime, to decide whether to extract now or in the future.

Example

- Two time periods: T0 and T1.
- Total reserve of non-renewable resource is 100 tonnes.
- Present price (P0) of the resource is Rs.20.
- MC = AC = Rs. 20
- Rate of discount is 10%
- By what rate should future price P1 increase to postpone extraction?

Conditions for Resource Conservation:

1) The expected future price P1, should be equal to Augmented Marginal Cost:

$$P1 = AMC = (MC + UC)$$

2) Future price P1 should exceed the present price P0 by the rate of discount:

$$P1 = P0\,(1+r)$$

- If $P0\,(1+r) < P1$ the mine owner will prefer to extract now.
- If $P0\,(1+r) \geq P1$ he will prefer to postpone extraction.

Discounted Future Price:

In our example p1 = p0 (1+r) = Rs.20 (1+ 0.1) = Rs.22.

So future price has to increase by Rs.2

The mine owner equates present earnings with discounted future earnings:

$$P_0Q_0 = (P_1Q_1)/ (1+r)$$

- 1st year earnings = Rs.20 × 30t = Rs.600
- 2nd Time period earnings = Rs.22 × 30t = Rs.660

- Discounting by the rate of interest of 10% = Rs.660/1.1 = Rs.600
- This satisfies the NPV rule that P0Q0 = (P1Q1)/ (1+r)

Hotelling's Fundamental Equation or Rule:

"The optimum path of depletion of a non-renewable resource is decided by the expected rise in future price at least by the rate of discount or interest."

- Along the optimal path of depletion of a non-renewable resource:
- The marginal net price, which is identical to the resource or Hotelling rent, should increase at the rate of discount.
- If the initial price is too high, there will be too much conservation in early years and a part of the resource stock will be left in the ground.
- If, on the other hand, *P0* is too low, there is over-exploitation, and the resource stock will be depleted too early.

Criticism:

1) If future prices are not properly predicted, leads to over or under exhaustion of the non-renewable resource.
2) The reserve position of the mine may not be known.
3) Changes in the rate of discount leads to fluctuations in the natural resources market.
4) In perfect competition, expectations do not rule. So an individual mine owner cannot change his production decisions. This is possible only in a monopoly.
5) MC of extraction may not remain constant.
6) No discussion of exhaustion of global minerals, and impact on development.

Back stop technology

•Hotelling's conceptual framework is expanded to incorporate the effects of a backstop technology on the planning horizon of the suppliers of an exhaustible resource and its price and quantity trajectories.

•It is shown that in the non-trivial case, the presence of a backstop technology shortens the planning horizon of the suppliers of the exhaustible resource in accordance with the resource suppliers' rate of time preference, backstop technology's rate of improvement and ratio of the initial resource spot price to the initial average production cost of the backstop substitute.

• As expected the presence of a backstop technology also lowers the spot prices of the exhaustible resource and accelerates its extraction and depletion. However, a decline of the initial average cost of producing the backstop substitute by a dollar leads to a decline of the exhaustible resource's initial spot price by less than a dollar.

Back stop technology

- A backstop technology is defined as a new technology producing a close substitute to an exhaustible resource by using relatively abundant production inputs and rendering the reserves of the exhaustible resource obsolete when the average cost of production of the close substitute falls below the spot price of the exhaustible resource.

- For instance, the technology of harnessing solar energy can be perceived as a backstop technology to oil, coal and natural gas. Hence, the development of a backstop technology shortens the planning horizon and, in turn, can accelerate the extraction and lower the spot prices of the exhaustible resource.

- Hotelling's conceptual framework was expanded to incorporate the effects of a backstop technology on the planning horizon of the suppliers of the exhaustible resource and its price and quantity trajectories.

Back stop technology

•Hotelling's fundamental rule and its implications for the equilibrium resource price and extraction trajectories when the resource was not threatened by a backstop technology were presented as a benchmark.

• It was shown that in the presence of a backstop technology the planning horizon of the suppliers of the exhaustible resource might be shortened and inversely related to the resource suppliers' rate of time preference, backstop technology's rate of improvement and ratio of the initial resource spot price to the initial average cost of production of the backstop substitute.

• By incorporating this endogenously determined planning horizon, the effects of the backstop technology on the exhaustible resource's price and extraction trajectories were analysed.

Back stop technology

•As intuitively expected, the presence of a backstop technology lowers the spot prices of the exhaustible resource and accelerates its extraction and depletion.

• However, a decline of the initial average cost of producing the backstop substitute by a dollar leads to a decline of the exhaustible resource's initial spot price by less than a dollar.

• Finally, by incorporating the effects of the backstop technology on both the planning horizon of the resource suppliers and the resource initial price, a framework for determining an efficient development path of the backstop technology was offered.

Property research

•The purpose of the property rights approach is to build on and merge with the standard theory of production and exchange in order to obtain an expanded scope of its validity.

• It argues that the purpose of trade and production is to exchange bundles of rights to do things with goods that are exchanged.

•Thus the value of the goods traded increases and the terms of trade improve with increases in the degree of property rights in those goods.

•It follows that the scope and content of property rights over resources affects the way people behave in a world of scarcity.

•The concept of property rights can be extended to various fields.

Property research

•One could think of the problem faced by a financially weak, independent inventor when selling a valuable but easily imitated invention for which no property rights exist.

•Most independent inventors cannot successfully create an organization to take commercial advantage of their invention, so they have to rely on another party.

• This involves a production contract, a licensing arrangement, or the outright sale of the invention.

Externalities

•Externalities occur in an economy when the production or consumption of a specific good or service impacts a third party that is not directly related to the production or consumption of that good or service.

•Almost all externalities are considered to be technical externalities.

•Technical externalities have an impact on the consumption and production opportunities of unrelated third parties, but the price of consumption does not include the externalities.

• This exclusion creates a gap between the gain or loss of private individuals and the aggregate gain or loss of society as a whole.

• The action of an individual or organization often results in positive private gains but detracts from the overall economy.

Externalities

• Many economists consider technical externalities to be market deficiencies, and this is the reason people advocate for government intervention to curb negative externalities through taxation and regulation.

• Externalities were once the responsibility of local governments and those affected by them.

•So, for instance, municipalities were responsible for paying for the effects of pollution from a factory in the area while the residents were responsible for their healthcare costs as a result of the pollution.

•After the late 1990s, governments enacted legislation imposing the cost of externalities on the producer. This legislation increased costs, which many corporations passed on to the consumer, making their goods and services more expensive.

Conversion of Uncertainity

•Uncertainty is central to environmental policy. For most environmental problems, we have very limited knowledge of the underlying physical or ecological processes, the economic impacts of environmental change, and the possible technological changes that might occur and ameliorate the economic impacts and/or reduce policy costs.

•If costs and benefits were linear and both environmental damage and policy costs were reversible, these uncertainties would not complicate matters much; policies could be based on expected values of costs and benefits at each point in the future.

•But as I have tried to show, cost and benefit functions tend to be highly nonlinear, and both environmental damage and policy costs are often irreversible. As a result, it can be misleading to base policies on expected values of costs and benefit