UNIT I
Introduction

Environmental economics is a subfield of economics concerned with environmental issues. Environmental Economics undertakes theoretical or empirical studies of the economic effects of national or local environmental policies around the world. In the early tradition of economic thought, laid down by the classical and neo-classical economists, economics was conceived as the study of the allocation of scarce resources among alternative, competing ends, in the quest to satisfy human wants. The classical and neo-classical economists underestimated the environmental issues of production and consumption, since they considered these as social issues. Consequently, the impacts of production and consumption on the natural environment were not explicitly brought into the mainstream of economic theory.

However in the early 1970s, the reality of economic thought brought to a halt the perception of economics merely as a science of production and distribution. In the new thinking, economics is no longer perceived as the science of production and distribution which neglects the environmental repercussions of economic activities. This means that economics as a subject cannot exist in isolation. It must take into consideration the effects of resource use in production and distribution on the natural environment which supplies these resource inputs. Thus, any study on the economic content of production, distribution, consumption, development etc cannot be completed without touching upon the environmental aspects like pollution of the environment (e.g water and air pollution), environmental damage, environmental resource exhaustion and depletion, global warming, biodiversity, social externalities and the likes.

In order to account for the environmental impact of economic activities, a new field of study called environmental economics thus emerged. The call for an evaluation of environmental impact of economic activities necessitates the regulation of these activities for environmental sustainability. This regulation therefore brings into fore the issue of

environmental policy, which nearly all countries all over the world now spend resources to formulate at national and international levels.

In order to account for the environmental impact of economic activities, a new field of study called environmental economics thus emerged. Although, this branch of economics can be traced to the 1950s and the 1960s, with important contributions from the think on resources for the future, the field really took off from the 1970s and has been booming ever since. Environmental economics can therefore be seen as an applied part of economics which deals with the entrepreneurship between economic activities and the environment and studies the way and means by which the former is not impeded nor the latter impaired.

DEFINITION OF ENVIRONMENTAL ECONOMICS

Environmental economics is concerned with the analysis of the impact of the economy on the environment, the significance of the environment to the economy and appropriate way of regulating economic activity so that balance is achieved among environmental, economic and other social objectives.

It should be noted that environmental study requires a synthesis of the various branches of knowledge like science, economics, philosophy, ethics, anthropology etc. Therefore, the study of the environment may be approached from different perspectives and environmental economics may borrow from such perspectives in its analysis.

NEED FOR A SPECIAL COURSE IN ENVIRONMENT ECONOMICS?

Environmental and natural resources should be allocated in the same way we want to allocate all resources. That is, efficiently and equitably. In this sense, there is no theoretical need to have a separate course for natural and environmental resources. Then why do we do courses in environmental and natural resource economics? Economic analysis of the environment is challenging and important precisely because environmental value is not always conveniently revealed in a market, and thus is subject to inappropriate use. Indeed, lots of people are particularly worried about the allocation of environmental

and natural resources. And, a lot of people think they are being misallocated. This has generated some concerns which gave credence to the separate treatment of environmental and natural resources. Some of these concerns are:

1. Natural resources are finite and stocks are dwindling, so may be the shit has to hit the fan sometime soon.
2. Increasing concern about non-catastrophic pollution. This result from increasing information about the effect of pollutant on health etc.
3. Concern about catastrophic pollution; that is, pollution that could lead to a widespread eco disaster such as green-house effect, loss of the ozone layer and radiation from bombs or leaks.
4. Concern over the preservation of natural environments: Wilderness areas, National Parks, the rain forests, the Arctic, etc, hence Green Association such as Sierra Club, Friends of the Earth, National Wildlife Federation etc.
5. Concern over preservation of animal species. The possibility of extinction is a growing concern for many species; hence we have conservation groups such as Greenpeace, World Wildlife Fund, Trout Unlimited, Ducks Unlimited etc.
6. Consequently, economist are increasingly being called upon to help guide the process of environmental management and to provide measurable criteria by which environmental policies can be evaluated. Hence, the need for a study on environmental economics.

THE SCOPE OF ENVIRONMENTAL ECONOMICS

As a sub discipline of economics, environmental economics originated early years of the so-called environmental movement. However, despite its brief history, over the past three decades it has become one of the fastest-growing fields of study in economics. The growing popularity of this field of inquiry parallels the increasing awareness of the interconnectedness between the economy and the environment-more specifically, the increasing recognition of the significant roles that nature plays in the economic process as well as in the formation of economic value.

The nature and scope of the issues addressed in environmental economics are quite varied and all-encompassing. Below is a list of some of the major topics addressed in this field of study.

- The causes of environmental degradation.
- The need to re-establish the disciplinary ties between ecology and economics.
- The difficulties associated with assigning ownership right to environmental resources.
- The trade-off between environmental degradation and economic goods and services. The ineffectiveness of the market, if left alone, in allocating environmental resources. Assessing the monetary value of environmental damage.
- Public policy instruments that can be used to slow, halt and reverse the deterioration of environmental resources and/or the overexploitation of renewable and non-renewable resources.
- The macroeconomic effects of environmental regulation and other resource conservative policies.
- The extent to which technology can be used as a means of ameliorating environmental degradation or resource scarcity, in general- that is, limits to technology.
- Environmental problems that transcend national boundaries, and thus require international cooperation for their resolution.
- The limits of economic growth.

The extent to which past experience can be used to predict the future events that are characterized by considerable economic, technological and ecological uncertainties. Ethical and moral imperatives for environmental resource conservation-concern for the welfare of future generations. The interrelationship among population, poverty and environmental degradation in thedeveloping countries of the world.

CONCEPT OF ENVIRONMENTAL ECONOMICS

Environment

The word environment has been derived from the French word Environer' which means to surround. Environment includes water, air and land, and their inter-relationships with human beings, other living creatures, plants and microorganisms. Environment provides basic services essential to humanity such as supporting life, supplying materials, energy and absorbing waste products. The services of environment are used by production and household sector in an economy. These include minerals such as coal, petroleum and a wide assortment of ores that can be processed into metals/metal alloys. Other resources include plant, soil and water components used directly in production processes. Life supporting services are also provided by environment. These are clean air, water and food etc.

Environmental Pollution

A change in the physical, chemical or biological characteristics of the air, water or soil that can affect the health, survival or activities of human beings or other living organisms in a harmful manner. In economics, pollution is termed as any loss of human well-being arising from physical environmental changes.

Natural Resources

Anything obtained from the physical environment to meet human needs relates to natural resources. Basic human needs are fulfilled by materials provided by nature itself. They are air, water, soil, minerals, coal, petroleum, animals and plants. These stocks of the nature, useful to mankind are called natural resources. In the primitive age, man had used only those resources that supported his life. But the process of economic growth and increase in population have led to mismanagement of natural resources.

There are two types of natural resources:

(i) Non-renewable resources

(ii) Renewable Resources.

(i) Non-renewable Resources

These resources were formed in millions of years and hence will get exhausted sooner or later. Some of the nonrenewable resources are coal, petroleum, natural gas,

minerals etc. The stock of these resources is limited. They are susceptible to be degraded in quantity and quality by the human activities.

(ii) Renewable Resources

These resources are present in unlimited quantity in the nature. They are solar radiation, air and water. These are not likely to be exhausted by human activities.

Ecology

Ecology and economics share the same etymology—OIKOS (House). In Ecology, it represents the study of our house, whereas in economics, it ensures the management of that place. Ecology concerned with the relationship between the physical environment (soil, water and air) and organism environment (plant and animal life etc.). Ecological economists have analysed the interdependence between the physical environment and economic activities in their models. According to them, some economic activities may be the cause of environmental degradation.

Industrial Ecology

Industrial Ecology is the means by which humanity can deliberately and rationally maintain a desirable carrying capacity, given continued economic, cultural and technological evolution. It is a system in which one seeks to optimize the total material cycle from virgin material, to finished material, to components, to product, to obsolete product and to ultimate disposal. Factors to be optimized include resources, energy and capital. Industrial ecology redefines waste as a starting material for another industrial process. It also seeks to structure the economy‘s industrial base along the lines of natural economic systems whose cyclical flows of material and energy are both efficient and sustainable.

Ecosystem

Ecosystem is a term applied to a particular relationship between living organism and their environment. An eco-system has two main components: (a) abiotic, and (b) biotic. All the non-living components of environment present in an ecosystem are known as abiotic components.

These include the inorganic and organic components and climatic factors. On the other hand, the living organisms of an ecosystem are known as its biotic components which include plants, animals and micro-organisms. Ecosystems may be affected by

anthropogenesis factors. They also face short and long run natural changes imposed from both within and outside the systems such as climatic changes.

Environmental Pollution as an Economic Problem

Environmental pollution is an economic problem because it requires us to make choices and to resolve conflicts of interests. It is an economic problem because the means by which pollution can be reduced are themselves resources using. Further, it also reduces the value of some resources that society has at its disposal. It means that pollution is a problem of scarcity in terms of waste disposal capacity. The main problem of choice is how to utilize the scarce resources in relation to society‘s needs. The market forces will be helpful in determining these scarce resources in most rational manner. The equilibrium will be attained at the equality of demand and supply of environmental quality. Since resources are scarce they cannot be used to produce all types of goods simultaneously. Therefore, if they were used to produce one thing, they have to be withdrawn from other uses. The problem of choice facing a modem society is whether to maintain environmental quality or to increase industrial production (i.e. automobiles). It creates conflicts of interest between potential gainers and potential losers. The problem of externalities is an important aspect of environmental quality. The external effects of industrial production may affect the environmental quality. Therefore, the economic problem is the optimal allocation of resources in the context of externalities. One of the objectives of environmental quality is to restrict those production activities which enhance social costs to society. Environmental quality is largely influenced by human activities in terms of excess exploitation of resources and the production of waste. How much environmental quality is affected by exploitation of resources and production of waste depends on ecological conditions of the economy.

SCOPE OF ENVIRONMENTAL ECONOMICS:

Environmental economics is considered both a positive and a normative science. Therefore, it has wide scope.

Economy-environment analysis

Environmental economics is primarily concerned with the impact of economic activities on environment and its implications for the individual firm, industry and the

economy as a whole. Economists have formulated economy-environment models to explain the various economic activities and their external effects. For example, the Material Balance Model and the Leontief Abatement Model explain these externalities.

Eco-development

The main objective of environmental economics is to maintain a balance between economic development and environmental quality. In order to achieve it, environmental economists have to explore the various socio-economic possibilities to reduce pollution and uplift the standard of living of the people. This objective gained momentum after the publication of the Report on Limits to Growth.

Welfare approach

Environmental economics has emerged as a discipline to tackle environmental problems from an economic welfare framework. The welfare framework covers scarce resources and market failures due to property rights and ethical aspects of different problems of pollution. Thus it suggests the best possible means to tackle the environmental problems.

Dynamic and stock-flow analysis

The mainstream economics is largely confined to the static problems of market behavior. But environmental management issues are about resources and are dynamic in nature. Moreover, resources have a stock and they have a rate of depletion and replenishment such as oil, minerals, and forests. Thus there is the inevitable stock-flow dimension to environmental issues.

Environmental values

Environmental issues are about resources. The neo-classical economists have analysed the use of various resources like fisheries, forests, fossil fuels and water in a rational manner and with environmental values. In fact, environmental values are economic values. It is important for the society to conserve its limited resources in the interest of economic efficiency and welfare.

Clean Technology

Presently environmental pollution is caused by misuse of existing technology and failure to develop better one. Environmental economists are in favour of appropriate and

clean technologies which provide the most rational use of natural resources and energy and to protect the environment.

International Cooperation

There are many international issues like hazards of trans-boundary shipments, unwanted substances and common property resources which need international cooperation among nations. There are many negative effects of inadequate toxic wastes generated within countries and hazardous goods exported to other countries. Most countries of the world are insisting on uniform standards and environmental regulations for all nations. Other issues are related to international common property resources, especially the share of river water and forest lands, etc.

Conservation Policy

The longstanding foundation of environmental economics lies in conservation economics which tends to emphasis the impact of economic activities on demand for productive resources and energy resources. It suggests the optimal strategy in the utilization of natural resources in a rational manner.

ENVIRONMENT - ECONOMY LINKAGES

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. There are three factors of production, natural, physical and human factors. Natural factors are directly connected with the environment.

Environmental cost benefit analysis and input-output analysis becomes integral part of mainstream economics. It is key consideration in all the decisions of production, factor allocation, pricing etc. There are two types of market systems, market oriented and state oriented. Market Oriented system creates more pollution problems than the state oriented system. 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. Environment Ministry implements this environment policy. This Ministry is considered as a 'super ministry', because all other ministries have to depend on this ministry.

II. Economics in Environmental Analysis:

Environment resources, their allocation and utilization are considered in the context of their economic cost benefit. The demand and supply, benefit and losses, equilibrium of environment resources all are analyzed in the context of economics. 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.

Scarcity of natural resources is crucial problem of developing countries. Economists can guide to environment analysis in obtaining maximum satisfaction of wants within the context of limited natural resources. Economics can guide environmentalists to decide that manner in which either maximum benefits or minimum loss would be obtained. We can explain pollution problems in economic terminology.

III. Environmental problems and their solution in Economies:

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. There should be no over utilization of natural resources. We should develop some basic standards for use of natural resources.

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.

Industrial and domestic wastes are the prime cause of water pollution and air pollution. Polluted water gets absorbed in land and creates land pollution. Economics has a solution for this. According to economics, air, land, water, river, ocean etc. are public goods which spread out pollution. We should control these polluted public goods.

V. Environment provides resource's 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. It provides services which are directly used by the consumers i.e. air we breathe and water we drink as a liquid of life. It provides forests, water reservoirs, rivers etc. and wildlife sanctuaries which also play economic roles for the mankind.

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 takes the non cyclical wastes and converts them back into harmless or ecologically useful products. It acts as a sink for all the waste products that are the result of the process of production and consumption. The environment is not a passive sink; it acts upon the waste products to clean up the environment.

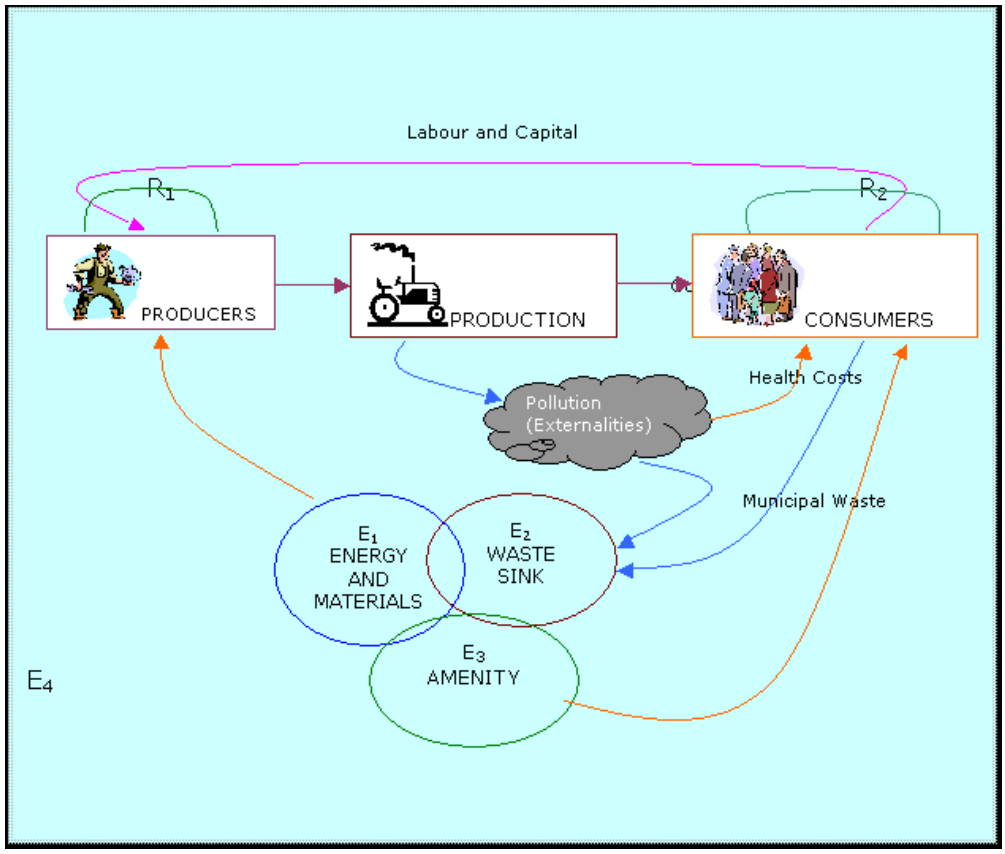


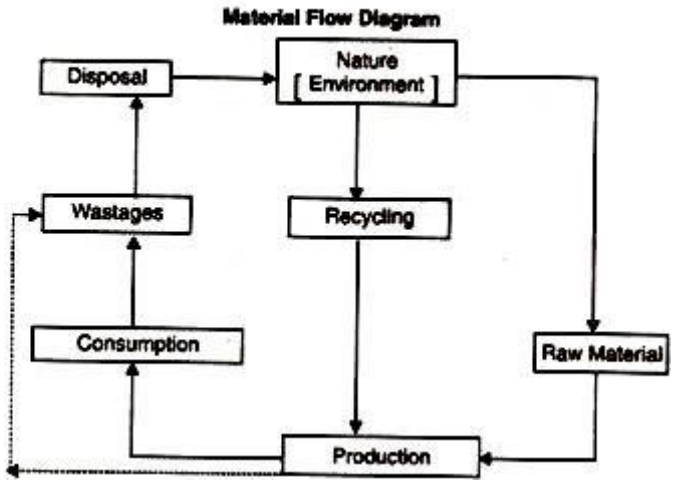
Figure 1.2 Linkage between Economy – Environment

Ayres-Kneese's Material Balance Model

In the words of Ayres and Kneese, —If waste assimilative capacity of the environment is scarce, the decentralized voluntary exchange process cannot be free of uncompensated technological external diseconomies unless all inputs are fully converted into outputs, with no unwanted material residuals along the way and all final outputs are utterly destroyed in the process of consumption. The functions of an economy are related to production, consumption and distribution activities. These activities have a direct relation with nature. Nature provides raw materials to the economy for its production and consumption activities. Residuals from both the production and consumption processes usually remain and they usually render disservices like killing fish, reducing public health, soiling and deteriorating buildings due to industrial pollution. Some wastes (residuals) from production and consumption activities are ultimately returned to nature. Remaining

wastages are recycled. Further, all emission of residuals do not cause pollution damage because of assimilative capacity of the environment.

Flow Diagram.



Further, energy that is taken out of the environment must reappear somewhere else in the economic system. Its form may, however, be changed so that it appears as waste products and gases. Moreover, waste energy cannot be recycled but waste materials can be used up to a point. It means that economic activity always affects environment in a direct or indirect manner. Thus the law of conservation of matter and energy holds that matter can be transformed to other matter or into energy but can never vanish. All inputs (fuels, raw materials, water and so forth) used in the economy‘s production processes will ultimately result in an equivalent residual or waste. The model is explained in the Material Flow Diagram. The material flow diagram implies that mass inputs must equal mass outputs for every process. Moreover, all resources extracted from the environment must eventually become unwanted wastes and pollutants. This means, among other things, externalities (market failures) associated with production and consumption of materials are actually pervasive and they tend to grow in importance as the economy itself grows. Materials recycled can help but recycling is energy intensive and imperfect, so it cannot fully compensate. According to John H. Baldwin, the conventional model of production and consumption omits important considerations. This omission results in emphasizing and managing only those sectors of production and consumption that are monetized.

Most real production and consumption of goods and services in the world, especially in developing countries, occur even outside the formal monetized economy. Hence, the materials balance model provides a useful framework for analyzing alternative methods of resource and residuals management. Thus, economics of the environment may be defined as a study which concerns allocation of resources among alternative uses in such a way that there is an efficient reduction of the waste or residuals in the environment, which lead to an increase in social welfare.

Its implications

The material balance model has important implications:

Disposal activities may affect both consumers and producers. The environment can act as a conduit for carrying the disposal activities. Business firms generally smoke into the air and this may affect the consumer‘s welfare. The consumers may also litter the landscape; produce vast quantities of trash and sewage. Each of these activities may affect each other. Because there are no markets regulating the flow of goods through disposal, there is also a possibility that too much of these activities will be carried on. Each will regard his disposal costs as zero and will use the environment so long as this use permits him to improve his own welfare.

2. The environment has a large waste assimilation capacity, but this is not infinite. Too much waste entering the environment rather than being recycled or reused will put too much stress on the assimilative capacity of the environment to handle such waste safety. The result will be a range of pollution and resources degradation impacts, and consequent economic damage cost.

3. With the application of the laws of thermodynamics, economic production and consumption activities always generate some pollution and waste. It requires proper disposal. Moreover, it is not always possible to have 100 percent recycling. Nevertheless, society does not have a choice over the total quantity of waste that its economic system produces.

4. In a general sense, policy makers can weigh up the social benefits of various productive activities and compare them with the social costs (including disposal) imposed by these activities. Policy makers may then decide to intervene in the economic process in order to change or modify production processes.

5. If a balance can be reached between acceptable levels of materials flows, there will be an increase in output and improvement in environmental quality.

6. From the policy point of view, this approach emphasizes recycle process and less residual-generating production process. It is only possible by modifying an environmental medium through investment in control facilities so as to improve its assimilative capacity. Investments involving public goods such as transportation systems, sewage disposal and river flow regulation are intimately related to the amounts and effects of residuals and must be planned in the light of them.

7. It is important to develop not only measures for the external costs resulting from different concentrations and duration of residuals in the environment but more systematic methods for forecasting emissions of external cost-producing residuals, technical and economic trade-offs between them, and the effects of recycle on environmental quality.

8. The application of the law of thermodynamics to the problem of waste is an important event in integrated residuals management. Residuals are generated by all production and consumption activities. This pervasive nature of the residuals problem, along with the inter-relationships of residuals, economic activities and recycling provides a physical system basis for environmental quality management. In other words it demonstrates that waste generation is pervasive to the economy. In turn, if the capacity of the environment to assimilate and degrade the waste into harmless form is limited, the externalities arising from the waste will be pervasive. This is in marked contrast to the view that externalities are occasional deviations from market perfection.

9. The importance of the materials balance principle lies in the fact that it provides a coherent framework in which an economic analysis of resources use and its implications for the environment can be placed. It draws one‘s attention to the long-term implications of economic activity, by focusing on the stock-flow relationships implied by that behaviour and its importance in this relationships.

Sustainable development

Sustainable development is an approach to economic planning that attempts to foster economic growth while preserving the quality of the environment for future generations. Despite its enormous popularity in the last two decades of the 20th century, the concept of sustainable development proved difficult to apply in many cases, primarily because the results of long-term sustainability analyses depend on the particular resources focused upon. For example, a forest that will provide a sustained yield of timber in perpetuity may not support native bird populations, and a mineral deposit that will eventually be exhausted may nevertheless support more or less sustainable communities. Sustainability was the focus of the 1992 Earth Summit and later was central to a multitude of environmental studies.

One of the most important areas of the law of sustainable development is ecotourism. Although tourism poses the threat of environmental harm from pollution and the overuse of natural resources, it also can create economic incentives for the preservation of the environment in developing countries and increase awareness of unique and fragile ecosystems throughout the world. In 1995 the World Conference on Sustainable Tourism, held on the island of Lanzarote in the Canary Islands, adopted a charter that encouraged the development of laws that would promote the dual goals of economic development through tourism and protection of the environment. Two years later, in the Malé Declaration on Sustainable Tourism, 27 Asian-Pacific countries pledged themselves to a set of principles that included fostering awareness of environmental ethics in tourism, reducing waste, promoting natural and cultural diversity, and supporting local economies and local community involvement. Highlighting the

growing importance of sustainable tourism, the World Tourism Organization declared 2002 the International Year of Ecotourism.

Current trends and prospects

Although numerous international environmental treaties have been concluded, effective agreements remain difficult to achieve for a variety of reasons. Because environmental problems ignore political boundaries, they can be adequately addressed only with the cooperation of numerous governments, among which there may be serious disagreements on important points of environmental policy. Furthermore, because the measures necessary to address environmental problems typically result in social and economic hardships in the countries that adopt them, many countries, particularly in the developing world, have been reluctant to enter into environmental treaties. Since the 1970s a growing number of environmental treaties have incorporated provisions designed to encourage their adoption by developing countries. Such measures include financial cooperation, technology transfer, and differential implementation schedules and obligations.

The greatest challenge to the effectiveness of environmental treaties is compliance. Although treaties can attempt to enforce compliance through mechanisms such as sanctions, such measures usually are of limited usefulness, in part because countries in compliance with a treaty may be unwilling or unable to impose the sanctions called for by the treaty. In general, the threat of sanctions is less important to most countries than the possibility that by violating their international obligations they risk losing their good standing in the international community. Enforcement mechanisms other than sanctions have been difficult to establish, usually because they would require countries to cede significant aspects of their national sovereignty to foreign or international organizations. In most agreements, therefore, enforcement is treated as a domestic issue, an approach that effectively allows each country to define compliance in whatever way best serves its national interest. Despite this difficulty, international environmental treaties and agreements are likely to grow in importance as international environmental problems become more acute.

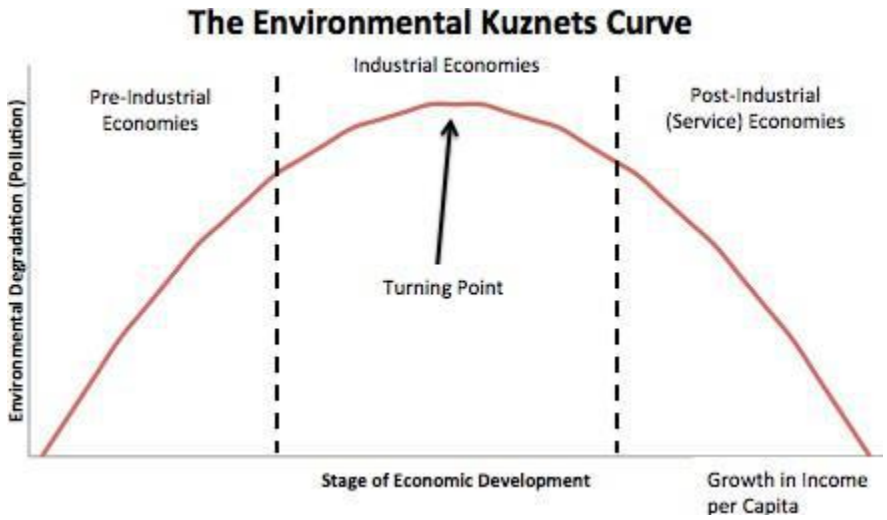
Many areas of international environmental law remain underdeveloped. Although international agreements have helped to make the laws and regulations applicable to some types of environmentally harmful activity more or less consistent in different countries, those applicable to other such activities can differ in dramatic ways. Because in most cases the damage caused by environmentally harmful activities cannot be contained within national boundaries, the lack of consistency in the law has led to situations in which activities that are legal in some countries result in illegal or otherwise unacceptable levels of environmental damage in neighbouring countries.

This problem became particularly acute with the adoption of free trade agreements beginning in the early 1990s. The North American Free Trade Agreement (NAFTA), for example, resulted in the creation of large numbers of maquiladoras—factories jointly owned by U.S. and Mexican corporations and operated in Mexico—inside a 60-mile- (100-km) wide free trade zone along the U.S.-Mexican border. Because Mexico's government lacked both the resources and the political will to enforce the country's environmental laws, the maquiladoras were able to pollute surrounding areas with relative impunity, often dumping hazardous wastes on the ground or directly into waterways, where they were carried into U.S. territory. Prior to NAFTA's adoption in 1992, the prospect of problems such as these led negotiators to append a so-called "side agreement" to the treaty, which pledged environmental cooperation between the signatory states. Meanwhile, in Europe concerns about the apparent connection between free trade agreements and environmental degradation fueled opposition to the Maastricht Treaty, which created the EU and expanded its jurisdiction.

Environmental Kuznets Curve

The environmental Kuznets curve (EKC), shows the relationship between economic progress and environmental degradation through time as an economy progresses. It describes that as countries develop initially, pollution increases. But later, as the economy achieves further development, pollution decreases. Empirical studies show that usually environmental factors like water, air etc. shows this path for several coutnries. Following

diagram shows that relationship between economic development and level of economic degradation.



The curve is known after economist Simon Kuznets who made a well-known study about the relationship between inequality and economic development. In that study also, the relationship between inequality and economic development gives an inverted U shape; showing an increase in inequality first with economic development and then, inequality decreases with further development and per capita income.

The inverted U shape (∩)

When the stages of economic development are expressed on the X axis and Environmental degradation on the Y axis, the Environmental Kuznet curve gives an inverted 'U' shape (∩).

The Environmental Kuznets curve shows an increasing pollution with initial development. But further economic progress brings down pollution. Reason for this decline in pollution with economic progress is that at low incomes, people tend to value development over environmental quality. They exploit resources and nature. With wealth accumulation, they are willing care more about environmental quality and its improvement.

The relationship between environment and economic activities is very strong. For example, uncontrolled expansion of economic activities has now caused global warming and climatic changes. Economic activities especially industrial activities have to be regulated for the protection of the environment.

Energy Economics

Energy economics is a broad scientific subject area which includes topics related to supply and use of energy in societies. Considering the cost of energy services and associated value gives economic meaning to the efficiency at which energy can be produced. Energy services can be defined as functions that generate and provide energy to the "desired end services or states". The efficiency of energy services is dependent on the engineered technology used to produce and supply energy. The goal is to minimise energy input required (e.g. kWh, mJ, see Units of Energy) to produce the energy service, such as lighting (lumens), heating (temperature) and fuel (natural gas). The main sectors considered in energy economics are transportation and building, although it is relevant to a broad scale of human activities, including households and businesses at a microeconomic level and resource management and environmental impacts at a macroeconomic level.

Or

Energy economics is the field that studies human utilization of energy resources and energy commodities and the consequences of that utilization. In physical science terminology, "energy" is the capacity for doing work, e.g., lifting, accelerating, or heating material. In economic terminology, "energy" includes all energy commodities and energy resources, commodities or resources that embody significant amounts of physical energy and thus offer the ability to perform work. Energy commodities - e.g., gasoline, diesel fuel, natural gas, propane, coal, or electricity – can be used to provide energy services for human activities, such as lighting, space heating, water heating, cooking, motive power, electronic activity. Energy resources - e.g., crude oil, natural gas, coal, biomass, hydro, uranium, wind, sunlight, or geothermal deposits – can be harvested to produce energy commodities. Energy economics studies forces that lead economic agents – firms, individuals,

governments – to supply energy resources, to convert those resources into other useful energy forms, to transport them to the users, to use them, and to dispose of the residuals. It studies roles of alternative market and regulatory structures on these activities, economic distributional impacts, and environmental consequences. It studies economically efficient provision and use of energy commodities and resources and factors that lead away from economic efficiency

Energy Conversion Processes

A fundamental property of energy is expressed by the first law of thermodynamics: energy can be neither created nor destroyed (except through nuclear reactions transforming matter to energy.) Energy can be converted between forms and human use of energy typically involves such conversions for human ends. Energy conversion processes are basic to human experience. Fire, providing heat and light, is a process by which chemical energy stored in the fuel, say, wood, is converted to thermal energy and radiant energy. Chemical energy stored in wood is the result of photosynthesis, whereby plants convert energy in sunlight to chemical energy, stored in the plant material. Carbohydrates in food are converted within the human body to thermal energy and mechanical energy, providing body warmth and movement. The industrial revolution was characterized by a change from use of hand tools, using human mechanical energy, to machine and power tools. Machine tools allowed conversion of energy in falling water to mechanical energy (water wheels) or conversion of chemical energy in wood or coal to mechanical energy (steam engines) for industrial processes. Humans now routinely harness complex sequences of energy conversion processes to provide desired services. Crude oil is separated into refined products such as gasoline, diesel oil, jet fuel, heavy distillates that embody chemical energy. Gasoline or diesel oil is explosively.

Depletable, Storable Renewable, Non-storable Renewable Resources

Based on the speed of natural processes, one can classify primary energy resources as depletable or renewable. Renewable resources can be further subdivided into storable or nonstorable resources. Renewable resources are self renewing within a time scale important for economic decision making. Storable renewable resources typically exist as a

stock which can be used or can be stored. Biomass, hydro power, and some geothermal, fall in this category. The amount used at one time influences the amount available in subsequent times. Nonstorable renewable resources – wind, solar radiation, run-of-the-river hydro resources can be used or not, but the quantity used at a given time has no direct influence on the quantity available subsequently. Most energy commodities are storable (refined petroleum products, processed natural gas, coal, batteries), but electricity is not storable as electricity. Depletable resources are those whose renewal speeds are so slow that it is appropriate to view them as made available once and only once by nature. Crude oil, natural gas, coal, and uranium all fall in this category. 11 Initially all human energy use depended on renewable resources, in particular biomass resources used for food, heat, or light. In the United States, renewable energy – human, animal, water, wood, and wind power – dominated energy supply through the middle of the 19th century. Only during the second half of the 19th century did a depletable resource, coal, surpass renewable resource use. Crude oil and natural gas started supplying large quantities of energy only in the 1920s.

Non-renewable energy:

Non-renewable energy comes from sources that will run out or will not be replenished in our lifetimes—or even in many, many lifetimes. Most non-renewable energy sources are fossil fuels: coal, petroleum, and natural gas. Carbon is the main element in fossil fuels Or Non-renewable resources are those which are available in fixed quantities. Examples include metal ores, oil and coal. In some texts such resources are referred to as exhaustible resources. However, this is misleading when there is resource exploration and the marginal cost of finding additional reserves and extracting known reserves increases as the resource is depleted. The key issues in the economics of non-renewable natural resources are, first, the rate at which a rational firm exploits the resource, second, the price path of the resource and how it changes through time; and third, the life-cycle of the resource, that is, how quickly it is economically exhausted. It is the fact of inevitable economic exhaustion which sets the economics of non-renewable resources apart from conventional capital theory.

Advantages and Disadvantages

Fossil fuels are a valuable source of energy. They are relatively inexpensive to extract. They can also be stored, piped, or shipped anywhere in the world. However, burning fossil fuels is harmful for the environment. When coal and oil are burned, they release particles that can pollute the air, water, and land. Some of these particles are caught and set aside, but many of them are released into the air. Burning fossil fuels also upsets Earth's "carbon budget," which balances the carbon in the ocean, earth, and air. When fossil fuels are combusted (heated), they release carbon dioxide into the atmosphere. Carbon dioxide is a gas that keeps heat in Earth's atmosphere, a process called the "greenhouse effect." The greenhouse effect is necessary to life on Earth, but relies on a balanced carbon budget. The carbon in fossil fuels has been sequestered, or stored, underground for millions of years. By removing this sequestered carbon from the earth and releasing it into the atmosphere, Earth's carbon budget is out of balance. This contributes to temperatures rising faster than organisms can adapt.

The Issue of Renewable Energy

There has been considerable interest recently in the topic of renewable energy. This is primarily due to concerns about environmental damage (especially acid rain and global warming) resulting from the burning of nonrenewable fossil fuels. However, investing in renewable energy is controversial for several reasons. First, not all scientists agree on the degree of environmental damage that can be attributed to fossil fuels. Second, fossil fuels are relatively abundant and cheap energy sources, and have contributed significantly to economic growth. Abandoning inexpensive fossil fuels for more expensive renewable ones will have major economic ramifications. Your students will enjoy analyzing this interesting and controversial topic.

Environmental Consequences of Energy Use Many important environmental damages stem from the production, conversion, and consumption of energy. Costs of these environmental damages generally are not incorporated into prices for energy commodities and resources; this omission leads to overuse of energy. Concern about this issue is common to energy economics, environmental economics (see environmental economics entry), and ecological economics (see ecological economics entry), with energy economics

and environmental economics literature attempting to assign monetary valuation of the impacts and ecological economics rejecting the idea that a monetary value could be placed on environmental impacts. Environmental impacts currently receiving most attention are associated with the release of greenhouse gases into the atmosphere, primarily carbon dioxide, from combustion of fossil fuels. The three primary fossil fuels – coal, petroleum, and natural gas – each include carbon. During combustion, carbon combines with oxygen to produce carbon dioxide, the primary greenhouse gas. Carbon dioxide accumulates in the atmosphere and is expected to result in significant detrimental impacts on the world's climate, including global warming, rises in the ocean levels, increased intensity of tropical storms, and losses in biodiversity. Fossil fuels account for 98% of the US carbon dioxide net releases into the atmosphere and 82% of the releases of greenhouse gases, measured on a carbon equivalent basis. Energy use leads to additional environmental damages. Coal combustion, particularly high sulfur coal combustion, emits oxides of sulfur, which, through atmospheric chemical reactions, result in acid rain. Automobile gasoline combustion releases oxides of nitrogen and volatile organic compounds, which, in the presence of sunlight, result in smog. Electric generating facilities often use much water for cooling and release the heated water into lakes or oceans, leading to local impacts on the ecosystem. Extraction of oil or mining of coal can lead to subsidence of the land overlying of the extracted deposits. Pervasive environmental impacts of energy use, absent governmental intervention, imply that significant costs of energy use are not included in the price energy users face. These so-called externalities (see environmental economics entry) lead to overuse of energy and provide strong motivation for interventions designed to reduce energy use.

ENERGY BASICS MEASURING ENERGY:

Energy can be defined as the capacity to do work. The unit of measurement used to express the heat contained in energy resources is called a British thermal unit or Btu. One Btu is the heat energy needed to raise the temperature of one pound of water one degree Fahrenheit. A Btu is quite small. For example, if allowed to burn completely, a wooden kitchen match gives off one Btu of energy. A quad is used to measure very large amounts of energy. A quad is equal to one quadrillion.

Coal

Coal is a black or brownish rock. We burn coal to create energy. Coal is ranked depending on how much "carbonization" it has gone through. Carbonization is the process that ancient organisms undergo to become coal. About 3 meters (10 feet) of solid vegetation crushed together into .3 meter (1 foot) of coal! Peat is the lowest rank of coal. It has gone through the least amount of carbonization. It is an important fuel in areas of the world including Scotland, Ireland, and Finland. Anthracite is the highest rank of coal. Anthracite forms in regions of the world where there have been giant movements of the earth, such as the formation of mountain ranges. The Appalachian Mountains, in the eastern part of the United States, are rich in anthracite. We mine coal out of the ground so we can burn it for energy. There are two ways that we can mine coal: underground mining and surface mining. Underground mining is used when the coal is located below the surface of the Earth, sometimes 300 meters (1,000 feet) deep—that's deeper than most of the Great Lakes! Miners take an elevator down a mineshaft. They operate heavy machinery that cuts the coal out of the Earth and brings it above ground. This can be dangerous work because cutting coal can release dangerous gases. The gases can cause explosions or make it hard for miners to breathe. Surface mining is used when the coal is located very near the surface of the earth. To get to the coal, companies must first clear the area. They take away the trees and soil. The coal can then be cut out of the ground more easily. Entire habitats are destroyed during this process. About half the electricity in the United States comes from coal. It gives power to our lights, refrigerators, dishwashers, and most other things we plug in. When coal is burned, it leaves "byproducts" that are also valuable. We use the byproducts to make cement, plastics, roads, and many other things.

Advantages and Disadvantages

Coal is a reliable source of energy. We can rely on it day and night, summer and winter, sunshine or rain, to provide fuel and electricity. Using coal is also harmful. Mining is one of the most dangerous jobs in the world. Coal miners are exposed to toxic dust and face the dangers of cave-ins and explosions at work. When coal is burned, it releases many toxic gases and pollutants into the atmosphere. Mining for coal can also cause the ground to cave in and create underground fires that burn for decades at a time.

Petroleum

Petroleum is a liquid fossil fuel. It is also called oil or crude oil. Petroleum is trapped by underground rock formations. In some places, oil bubbles right out of the ground. At the LaBrea Tar Pits, in Los Angeles, California, big pools of thick oil bubble up through the ground. Remains of animals that got trapped there thousands of years ago are still preserved in the tar! Most of the world's oil is still deep under the ground. We drill through the earth to access the oil. Some deposits are on land, and others are under the ocean floor. Once oil companies begin drilling with a "drill rig," they can extract petroleum 24 hours a day, seven days a week, 365 days a year. Many successful oil sites produce oil for about 30 years. Sometimes they can produce oil for much longer. When oil is under the ocean floor, companies drill offshore. They must build an oil platform. Oil platforms are some of the biggest manmade structures in the world! Once the oil has been drilled, it must be refined. Oil contains many chemicals besides carbon, and refining the oil takes some of these chemicals out. We use oil for many things. About half of the world's petroleum is converted into gasoline. The rest can be processed and used in liquid products such as nail polish and rubbing alcohol, or solid products such as water pipes, shoes, crayons, roofing, vitamin capsules, and thousands of other items. *Advantages and Disadvantages*There are advantages to drilling for oil. It is relatively inexpensive to extract. It is also a reliable and dependable source of energy and money for the local community. Oil provides us with thousands of conveniences. In the form of gasoline, it is a portable source of energy that gives us the power to drive places. Petroleum is also an ingredient in many items that we depend on. However, burning gasoline is harmful to the environment. It releases hazardous gases and fumes into the air that we breathe. There is also the possibility of an oil spill. If there is a problem with the drilling machinery, the oil can explode out of the well and spill into the ocean or surrounding land. Oil spills are environmental disasters, especially offshore spills. Oil floats on water, so it can look like food to fish and ruin birds' feathers.

Natural Gas

Natural gas is another fossil fuel that is trapped underground in reservoirs. It is mostly made up of methane. You may have smelled methane before. The decomposing

material in landfills also release methane, which smells like rotten eggs. There is so much natural gas underground that it is measured in million, billion, or trillion cubic meters. Natural gas is found in deposits a few hundred meters underground. In order to get natural gas out of the ground, companies drill straight down. However, natural gas does not form in big open pockets. Natural gas is trapped in rock formations that can stretch for kilometers. To reach natural gas, some companies use a process called "hydraulic fracturing," or fracking. *Hydraulic* means they use water, and *fracturing* means to "split apart." The process uses high-pressure water to split apart the rocks underground. This releases the natural gas that is trapped in rock formations. If the rock is too hard, they can send acid down the well to dissolve the rock. They can also use tiny grains of glass or sand to prop open the rock and let the gas escape. We use natural gas for heating and cooking. Natural gas can also be burned to generate electricity. We rely on natural gas to give power to lights, televisions, air conditioners, and kitchen appliances in our homes. Natural gas can also be turned into a liquid form, called liquid natural gas (LNG). LNG is much cleaner than any other fossil fuels. Liquid natural gas takes up much less space than the gaseous form. The amount of natural gas that would fit into a big beach ball would fit into a ping-pong ball as a liquid! LNG can be easily stored and used for different purposes. LNG can even be a replacement for gasoline. *Advantages and Disadvantages*Natural gas is relatively inexpensive to extract, and is a "cleaner" fossil fuel than oil or coal. When natural gas is burned, it only releases carbon dioxide and water vapor (which are the exact same gases that we breathe out when we exhale!) This is healthier than burning coal. However, extracting natural gas can cause environmental problems. Fracturing rocks can cause mini-earthquakes. The high-pressure water and chemicals that are forced underground can also leak to other sources of water. The water sources, used for drinking or bathing, can become contaminated and unsafe.

Other Non-renewable Energy Sources

Fossil fuels are the leading non-renewable energy sources around the world. There are others, however. Nuclear energy is usually considered another non-renewable energy source. Although nuclear energy itself is a renewable energy source, the material

used in nuclear power plants is not. Nuclear energy harvests the powerful energy in the nucleus, or core, of an atom. Nuclear energy is released through nuclear fission, the process where the nucleus of an atom splits. Nuclear power plants are complex machines that can control nuclear fission to produce electricity. The material most often used in nuclear power plants is the element uranium. Although uranium is found in rocks all over the world, nuclear power plants usually use a very rare type of uranium, U-235. Uranium is a non-renewable resource. Nuclear energy is a popular way of generating electricity around the world. Nuclear power plants do not pollute the air or emit greenhouse gases. They can be built in rural or urban areas, and do not destroy the environment around them. However, nuclear energy is difficult to harvest. Nuclear power plants are very complicated to build and run. Many communities do not have the scientists and engineers to develop a safe and reliable nuclear energy program. Nuclear energy also produces radioactive material. Radioactive waste can be extremely toxic, causing burns and increasing the risk for cancers, blood diseases, and bone decay among people who are exposed to it. *Biomass Energy*Biomass energy, a renewable energy source, can also be a non-renewable energy source. Biomass energy uses the energy found in plants. Biomass energy relies on biomass feedstocks—plants that are processed and burned to create electricity. Biomass feedstocks can include crops such as corn or soy, as well as wood. If people do not replant biomass feedstocks as fast as they use them, biomass energy becomes a non-renewable energy source**.**

Economic Implications Energy policies have many economic implications. Two somewhat controversial issues concern the distinction between energy efficiency and economic efficiency, and the role of market prices in guiding decisions about energy resources.

ENERGY EFFICIENCY VERSUS ECONOMIC EFFICIENCY:

Economists are concerned with the overall economic efficiency of the economic system. This means getting the greatest benefit from all of our scarce productive resources. Energy efficiency is a narrower concept, and means getting the greatest benefit from our

energy resources. Sometimes these goals conflict. A goal of maximizing energy efficiency puts no value on the other scarce resources. For example, we could make automobiles today that average more than 100 miles per gallon. This would result in better energy conservation, but would we be willing to pay the cost in terms of lack of power and crash protection.

THE ROLE OF PRICE IN GUIDING DECISIONS ABOUT ENERGY:

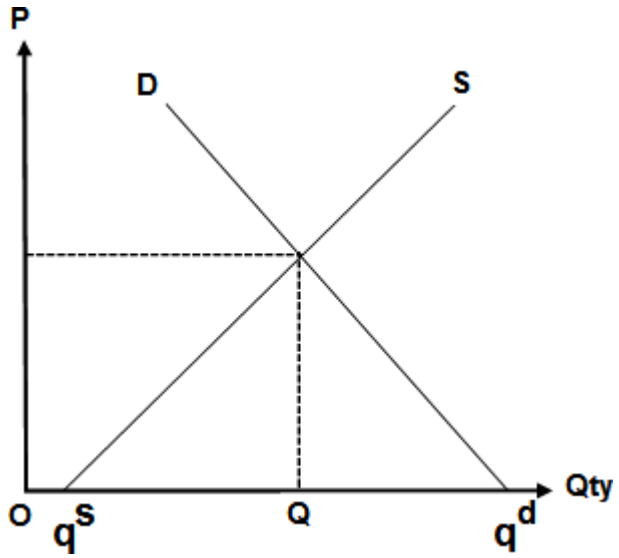
In market economies resource allocation is guided by market prices. They help society determine answers to the crucial questions of what, how, and for whom to produce. However, in the area of energy policy, many advocate significant levels of government intervention in energy markets. The intervention often takes the form of subsidies for the development of renewable energy sources. For example, the market price of oil is currently about $20 a barrel. This price is high enough for oil producers to make a profit. At this price, oil is also relatively inexpensive for consumers and producers of other goods and services, who enjoy many benefits from this valuable source of energy. The relatively low market price of oil indicates that oil is an abundant source of energy at this time. Should the government subsidize more expensive forms of renewable energy given the low price of oil (and other fossil fuels)? Proponents contend that subsidies are necessary to help reduce our dependence on finite fossil fuels. Proponents also point out that relying more on renewable energy will reduce our dependence on foreign oil suppliers, and will result in less pollution of the environment. Subsidy opponents argue that we will never run out of fossil fuels. As fossil fuels become more scarce, their market price will rise, encouraging consumers to use less. The higher price also will make it cost effective for energy companies to invest in new fossil fuel production technologies and to invest in alternative energy sources, including renewable energy. This simultaneous decrease in the quantity of energy demanded and increase in the quantity of energy supplied, occurs automatically, without costly and inefficient government intervention. Opponents of subsidies agree that the environmental costs of fossil fuels should be reflected in their price, and this should be an important consideration when dealing with this issue. They believe that the best way to lessen the danger of a cut-off in foreign supplies is to build a strategic petroleum reserve. The issue of the development of renewable energy sources is a complicated one. The key

point to remember is that there is an opportunity cost to every economic decision. Using tax revenues to subsidize renewable energy means giving up some other valuable use for those revenues. In energy policy, as in all public policy, decision makers must consider all the opportunity costs when determining trade-offs among different policy goals

SCARCITY AND RESOURCES

The Concept of Scarcity

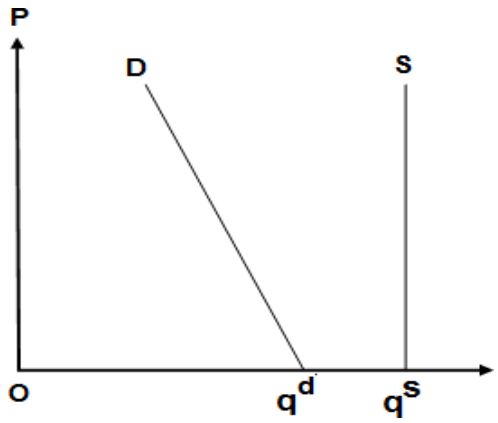
Definition: A scarce resource is one which, when offered to people at no cost, more would be wanted (demanded) than is available (supplied). Notice that the opposite of a scarce resource is afree resource. At no price, the quantity supplied of a free good for instance exceeds the quantity demanded leading to a surplus. The definition of scarcity above is further explained graphically as shown below:



From the above figure; it stated that, demand and supply and market clearing (equilibrium) price for a scarce resource. Notice that at zero price (on the price axis, zero price coincides with the origin), quantity demanded is $q^d$and quantity supplied is

q^s. Notice further that q^d far exceeds q^s, creating a shortage or scarcity.

On the other hand, at zero price, the quantity demanded of a free good is smaller than the quantity supplied, creating a surplus. Consider oxygen which is freely supplied by nature, the availability of oxygen from the ambient air (supply) far exceeds the quantity demanded in a non- polluted environment. Thus oxygen may be treated as a free good. The demand and supply analysis for a free good is drawn below.



Notice that at zero price (point on the origin), the quantity supplied far exceeds the quantitydemanded as q^S is greater than q^d, counting from the origin. In economics, the situation of scarcity arises when there is less of an economic good, service or resource than people would like to have if it were free. Scarcity reflects the fact that there are not sufficient resources (inputs) to produce everything that individuals want.

It should be noted that in the absence of scarcity, no difficult choices would need to be made and hence no opportunity or real cost, no prices would need to be attached to anything, and the study of economics would be rendered entirely unnecessary. Furthermore, as the economist uses the concept, scarcity is present in all societies whether rich or poor in as much as there is a gap between resource need and resource availability.

RESOURCE EXHAUSTION, BACKSTOP TECHNOLOGY AND LIMITS TO GROWTH

We have seen in this chapter that depletion of a nonrenewable resource is accompanied by a steady increase in price. Thus, increasing scarcity of a nonrenewable resource is associated with ever-increasing cost; this, in some ways, seems to support the classical doctrine of increasing resource scarcity

A backstop technology provides an alternative to the nonrenewable re- source. Solar and wind power, and other methods of generating electricity, are backstop technologies for fossil fuels. We assume that the backstop is a perfect substitute for the resource, can be produced at a constant average cost b, and can be supplied without limit. In contrast, the natural resource has a finite potential supply, given by the stock level. The backstop is available to the economy at large; any firm can use it.

Externalities:

An externality exists when the consumption and production choices of one person or firm enter the utility or production function of another entity without that entity's permission or compensation. An Externality occurs when one persons or firm's actions affect another entity without permission. If an individual wants to play his stereo loudly, his neighbours must listen as well. Let us understand the term Externality by means of an example, laundry shop and a steel mill.

Or

Externalities are unintentional side effects of an activity affecting people other than those directly involved in the activity.

Positive Externality

A positive externality, on the other hand, is an unpaid benefit that extends beyond those directly initiating the activity. One example would be a neighborhood resident who creates a private garden, the aesthetic beauty of which benefits other people in the community. Also, when a group voluntarily chooses to create a benefit, such as a community park, others may benefit without contributing to the project. Any individuals or groups that gain additional benefits without contributing are known as "**free riders**".

Negative Externality

A negative externality is one that creates side effects that could be harmful to either the general public directly or through the environment. An example would be a factory that pollutes as a result of its production process. This pollution may pose health risks for nearby residents or degrade the quality of the air or water. Either way, the owner of the factory does not directly pay the additional cost to address any health issues or to help maintain the cleanliness of the air or water. In some cases, however, the harmed parties can use legal measures to receive compensation for damages.

Traditionally, both negative and positive externalities are considered to be forms of market failure - when a free market does not allocate resources efficiently. **Arthur Pigou**, a British economist best known for his work in welfare economics, argued that the existence of externalities justified government intervention through legislation or regulation. Pigou supported taxes to discourage activities that created harmful effects and subsidies for those creating benefits to further encourage those activities. These are now known as **Pigovian.**

Types of Externalities*:* Externalities can be unidirectional or reciprocal which means simply that if A imposed an externality on B and B has not imposed an externality on A, the externality is unidirectional. If B imposed an externality on A as well, then the externalities are reciprocal. Further classification of externalities is whether they are marginal or intra marginal. If they are marginal and unidirectional then A's behavior at the margin affects B's utility or profit. If they are intra marginal, then A can marginally, adjust his behavior without any change in the external effect on B. This will become clear in the examples of the various types of externalities, which are to follow:

i. A Marginal, Uni-Directional Externality:

An important example is the disutility to pedestrians caused by the emission of exhaust fumes by motor-cars.

ii. Marginal Reciprocal Externalities:

An example of this is when people who enjoy smoking but do not enjoy inhaling smoke that has been exhaled by other smokers respond to other's smoking by smoking themselves.

iii. An Intra Marginal, Uni-Directional Externality:

A lake may be unsuitable for swimming if too much of certain types of effluents are discharged into it but it may be able to accommodate a large inflow of additional effluents and hence the marginal adjustments in the outflow over a certain range do not alter the extent of the damage.

iv. Intra-Marginal Reciprocal Externalities:

When two radio listener people are in close proximity to each other. On a beach one may be disturbed if the other operates a radio. If each attempts to raise the volume of his radio to overcome the other's volume then it is possible that, over a range of volumes, their welfare is unchanged. In this situation the externalities are intra marginal. The absence of the existence of the above—mentioned externality is the precondition in determining the efficiency of perfect competitive market. This has led to the evolution of the concept of market failure.

Market Failure in Accounting External Economics:

In the context of environmental economics, the most important source of market failure is the divergence between the producer's evolution of the costs of his activities and the valuation by society as a whole. This divergence typically arises because of the presence of what are variously called 'external effect', 'spill-overs', 'neighbourhood effects' and 'third party effects'.

SCARCITY AND ITS ECONOMIC IMPLICATIONS

At the root of any economic study is the issue of resource scarcity. In fact, as a discipline, economics is defined as the branch of social science that deals with the allocation of scarce resources among competing ends. For economists, scarcity is the universal economic problem. Every human society, whether a tribal society such as the Aborigines in Australia or an economically and technologically advanced society such as Japan, is confronted with the basic problem of scarcity. This question clearly suggests that the significant economic problem involves *rationing* limited resources to satisfy human wants and, accordingly, has the following four general implications:

1 ***Choice*** The most obvious implication of scarcity is the need to choose. That is, in a world of scarcity, we cannot attain the satisfaction of all our material needs completely. Hence, we need to make choices and set priorities.

2 Opportunity cost Every choice we make has a cost associated with it; one cannot get more of something without giving up something else. In other words, an economic choice always entails sacrifice or opportunity cost—the highest-valued alternative that must be sacrificed to attain something or satisfy a want. In a world of scarcity, "there is no such thing as a free lunch."

3 Efficiency In the presence of scarcity, no individual or society can afford to be wasteful or inefficient. The objective is, therefore, to maximize the desired goods and services that can be obtained from a given set of resources. *This state of affairs is attained when resources are fully utilized (full employment) and used for what they are best suited in terms of production (i.e., there is no misallocation of resources).* Furthermore, efficiency implies that the best available technology is being used.

4 ***Social institutions*** As noted earlier, the essence of scarcity lies in the fact that people's desire for goods and services exceeds society's ability to produce them at a point in time. In the presence of scarcity, therefore, the allocation and distribution of resources always cause *conflicts*. To resolve these conflicts in a systematic fashion, some kind of institutional mechanism(s) needs to be established. For example, in many parts of the contemporary world, the *market system* is used as the primary means of rationing scarce resources. How this system operates conceptually is briefly discussed in the next section.

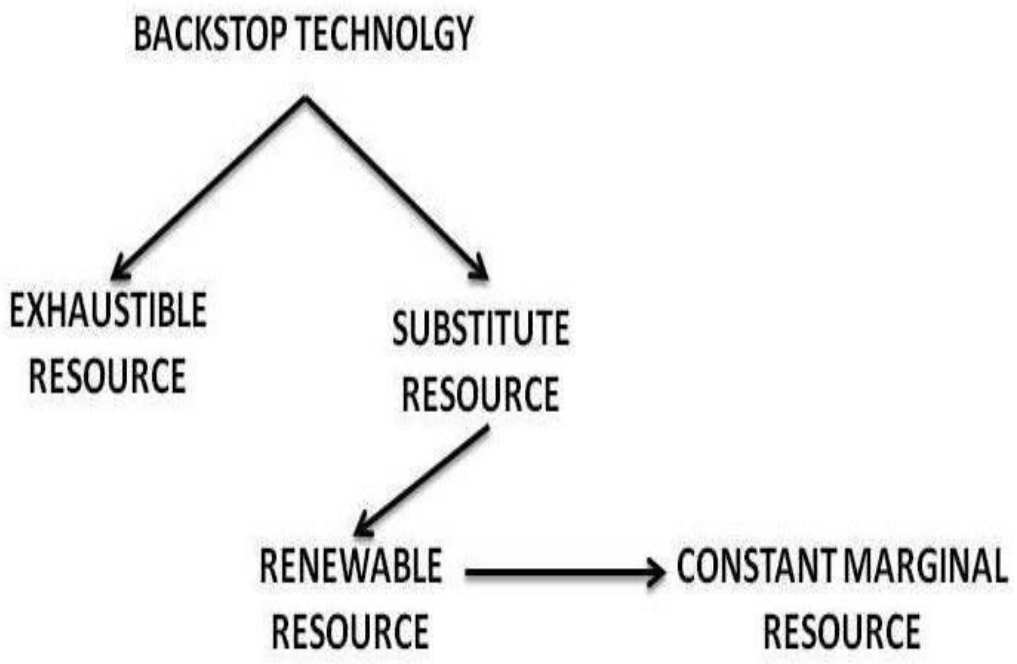
BACKSTOP TECHNOLOGY

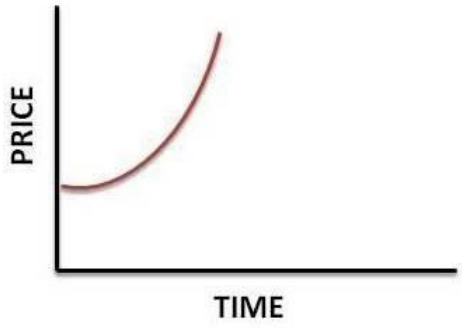
Meaning of Backstop: We all know that as the demand for a resource that is in limited supply increases, it will kick in a process that results in the exploitation of other alternative resources to meet human needs. For instance, as the demand for oil increases even as its available supply decreases, this will cause the price of oil to shoot up and push businesses to look for alternative sources of energy. This alternative source of resources is known as "backstop". So, backstop is nothing, but the substitute resources to exhaustible resources. Optimal depletion and Price of Non-Renewable Resources in presence of Backstop So far, we have considered optimal depletion of an exhaustible resource, we implicitly ruled out availability of any substitute or backstop. But it may happen that a

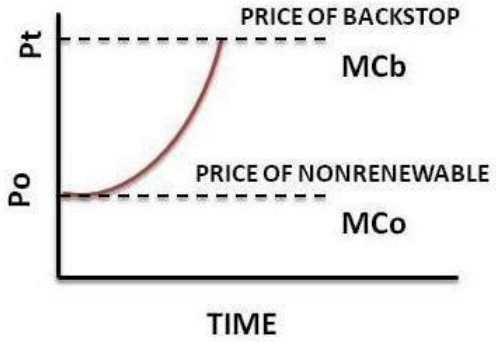
substitute resource, possibly a renewable resource, is available at a constant MC. For example, a backstop of oil or natural gas may be solar substitute. Then the question arises what would be the optimal depletion rule in these circumstances? Suppose that this alternative, or "backstop" resource, which is perfectly substitute of the non-renewable resource, can be supplied at some high cost but in fairly large quantities so that it is inexhaustible for all practical purposes. Since the backstop has a virtually unlimited supply, its price will be just sufficient to cover its marginal extraction cost. Implicitly, backstop technologies are assumed to be renewable. Ethanol fuel from renewable corn and sugar is frequently seen as a backstop for petroleum. In the presence of a backstop, there is a ceiling on the net price of the non-renewable resource. In theory, as soon as the price of the non-renewable resource just exceeds the price of the backstop, the former will be priced out of the market and the demand would be entirely satisfied by the latter resource. (In effect, the price of the backstop is like the vertical intercept on the linear demand curve for the non-renewable resource.) The overall result is the same as in the case with multiple sources of the same nonrenewable resource. The net price of the non-renewable resource will rise at the interest rate till it is completely exhausted. Exactly at that instant the net price would be equal to the price of the backstop and production would shift from the non-renewable to the backstop resource. It is easy to argue that in the absences of a backstop, the non-renewable resource would be depleted at exactly the time when production shifts to the backstop. Suppose this is not the case and there are some remaining reserves of the non-renewable resource when its price rises to that of the backstop. Then the resource owner would be unable to sell the resource on the market since the net price necessary to cover the scarcity rent would exceed the price of a cheaper substitute. The only option is to sell the resource at an earlier and lower price. However, this would increase the supply in the market and the net price would fall. In fact, the price would decline to a level such that when it rises at the interest rate the resource is exhausted at the price of the backstop. A similar argument emerges in the situation where the resource is exhausted before its price reaches the ceiling set by the backstop. In this case, there is a large excess demand which would bid up the price for the resource. The profit-maximizing resource owner would then hold back some reserves to sell at the future higher price and the production horizon would be extended. The above example assumes the supply curve for the backstop is

horizontal at a price just sufficient to cover its marginal extraction cost. This assumption is not necessary. It is entirely possible that the price of the backstop is rising slowly. As long as the backstop price is rising slower than the interest rate, then the price trajectories for the non-renewable resource and the backstop will intersect at some point. At that point, the price of the backstop will become the ceiling for the price of the non-renewable resource and the latter resource will be completely depleted. From that point on, the market will be completely supplied by the backstop. Figure 1shows the intersection of the price trajectories for the non-renewable and backstop resources, where Pnr indicates the price of the non-renewable resource, Pb indicates the price of the backstop, and Tnr indicates the depletion of the non-renewable resource.

In the static model, competitive supply in a period depends on the price in that period. In the nonrenew- able resource setting, however, current supply depends on current and future prices. The inter-relationship of markets across periods, in the resource setting, is analogous to the inter-relation of markets in the trade setting.







$$P_{T=} M_C + (P_O - M_C)(1+r)^T$$

$$MCb = M_C + (P_O - M_C)(1+r)^T$$

$$(P_O - M_C) = \frac{M_C - MCb}{(1+r)^T}$$

$$P_t = M_C + \frac{M_C - MCb}{(1+r)^T} \times (1+r)^t$$

$$P_t = M_C + \frac{M_C - MCb}{(1+r)^{T-t}}$$

Design and Implementation of Environmental Policy

3.1 Problems of measurement

We discuss some problems of measurement of environmental values:

1. Market Prices:

When there are adverse health effects and loss in productivity due to environmental damage, market pieces are to evaluate them. The procedure is to evaluate damages due to soil erosion, deforestation, and air and water pollution. For this purpose, the ecological relationship between environmental damages and its effects on production or health are estimated on the basis of prices to derive monetary values. Welfare losses relating to health risks due to polluted environment are measured by income foregone because of illness or premature death. Such estimates are difficult to compute because they rely on loss in income.

***2. Costs of Replacement*:**

People and firms invest in installing alternate devices to avert environmental damage of air, water and land. Such investments can provide an estimate of environmental damage. But the effects of damages cannot be evaluated.

3. Surrogate Markets:

The effects of environmental damages on other markets like property values and wages of workers are also evaluated. Valuation in the case of property is based on risks involved in evaluating the value of property due to environmental damage. Similarly, jobs with high environmental risks will have high wages which will include larger risk premiums. But this technique is impracticable because property owners and workers are ignorant of the effects of environmental damages.

4. Social Discount Rate:

Environmental degradation leads to costs and environmental improvements confer benefits on resource users. The problem of measuring environmental damage is to evaluate it and compare it with the cost of preventing it. It concerns comparing the benefits of environmental protection with the costs incurred on it. But the main problem is how to measure costs and benefits of environmental effects on the present and future generations. For this, a rate of discount is needed for discounting all costs and benefits. But there is lot of confusion and differences among economists in discounting environmental costs and benefits on the following grounds: Critics do not favour discounting in general and high discount rates in particular. According to them, there is no unique relationship between high discount rates and environmental degradation. When discount rates are high, the level of investment falls which discourages development projects and slows down the pace of development. It thus shifts the burden of high costs to future generations. Even demand declines for resources on which investments are to be made. However, the main problem is how to choose a social discount rate. This cannot be the market rate of interest because of uncertainties and imperfections of capital markets. Therefore, the majority of economists measure the social rate of discount at government's borrowing rates on long-term securities because they are riskless. But there are numerous borrowing rates on government securities relating to different time periods. The problem is which rate to choose as the social discount rate. Many economists, therefore, favour social rate of time

preference and opportunity cost of capital in measuring the cost and benefit of environmental degradation. But like the social discount rate, they have their problems of measurement and the effects on environmental degradation on the present and future generations are unclear.

3.2 Obstacles to determination of environmental policy

One of the main reasons for this is that the there is no independent regulatory body for environmental governance. Due to excessive interference by government there is poor implementation of environmental law. There is also a lack of political will and public awareness. Almost all laws related to environment consider the superiority of human over ecosystem and nature. We have an ineffective pollution control mechanism. The present frameworks mostly follow command and control structure. Industries are obligated to take permission from the regulators to discharge effluents and causing emissions but there is laxity in compliance due to lack of strong penalty measures. There is lack of independence given to the regulators who mostly have to depend on the government for the appointment. This leads to a lack of competent people. The appointment is at the wish of the government. Regulators don't have legal authority and their decisions tend to be overruled by the government. There is also a lack of funds to the regulators and they don't even have proper infrastructure or laboratories. There are certain laws which are not very elastic. The existing laws give importance to some specific types of pollution or specific categories of hazardous substances. The present mechanism fails to accept the polluter pay principle. Environmental Litigation is more expensive compared to other disputes as it involves expert testimony and technical evidences

Three issues that are especially important for environmental legislation are:

1. The precautionary principle:

This principle has evolved to deal with risks and uncertainties faced by environmental management. The principle implies that an ounce of prevention is worth a pound of cure it does not prevent problems but may reduce their occurrence and helps ensure contingency plans are made. The application of this principle requires either cautious progress until a development can be judged 'innocent', or avoiding development

until research indicates exactly what the risks are, and then proceeding to minimize them. Once a threat is identified, action should be taken to prevent or control damage even if there is uncertainly, about whether the threat is real. Some environmental problems become impossible or costly to solve if there is delay, therefore waiting for research and legal proof is not costless.

2. ***The polluter-pays principle:***

In addition to, the obvious the polluter pays for the damaged caused by a development this principle also implies that a polluter pays for monitoring and policing. A problem with

this approach is that fines may bankrupt small businesses, yet be low enough for a large company to write them off as an occasional overhead, which does little for pollution control. There is, thus, debate as to whether the principle should be retrospective. Developing nations are seeking to have developed countries pay more for carbon dioxide and other emissions controls, arguing that they polluted the global environment during the Industrial Revolution, yet enjoy the fruits of invention from the era. This principle, in fact, is more a way of allocating costs to the polluter than a legal principle.

***3. Freedom of information*:**

Environmental planning and management is hindered if the public, NGOs or even official bodies are unable to get information. Many countries have now begun to release more information, the USA has a Freedom of Information Act, and the European Union is moving in this direction. But still many governments and multinational corporations fear that industrial secrets will leak to competitors if there is too much disclosure, and there are situations where authorities declare strategic needs and suspend disclosure.

UNIT – II

Environmental degradation

Environmental degradation

Environmental degradation is the deterioration of the environment through depletion of resources such as air, water and soil; the destruction of ecosystems; habitat destruction; the extinction of wildlife; and pollution. Environmental degradation is of many types such as: Land and soil degradation, Water Degradation, Atmospheric Degradation

Land and Soil Degradation

This results from the excessive use of nature. Soil quality is essential for microorganisms and all plants, but due to human interference, its quality is declining. Poor farming practices, excessive usage of fertilizers and pesticides are the leading cause of this degradation.

Water Degradation

Water is a crucial natural component for both animals and plants. So, we need to keep it pure and pollution-free. The discharge of fertilizers, industrial waste, and some compounds' biological activity are some of the deadly causes of water degradation.

Atmospheric Degradation

We need atmospheric gases for our survival. However, pollution or degradation of the atmosphere pushes the world into a dark future. The increasing number of automobiles, industries, and other electrical for mechanical components are the leading causes of atmosphere degradation. One of which includes the increased rate of greenhouse gases which results in global warming and ozone depletion like problems.

Causes of Environmental Degradation

Some environmental life species require substantial areas to help provide food, living space, and other different assets. These creatures are called area specific. At the point when the biome is divided, the vast patches of living space don‘t exist anymore. It gets to be more troublesome for the wildlife to get the assets they need in order to survive. The environment goes on, even though the animals and plant life are not there to help sustain it properly.

- **Land Disturbance:** A more basic cause of environmental degradation is land damage. Numerous weedy plant species, for example, garlic mustard, are both foreign and obtrusive. A rupture in the environmental surroundings provides for them a chance to start growing and spreading. These plants can assume control over nature, eliminating the local greenery. The result is a territory with a solitary predominant plant that doesn‘t give satisfactory food assets to all the environmental life. Whole environments can be destroyed because of these invasive species.
- **Pollution:** Pollution, in whatever form, whether it is air, water, land or noise is harmful to the environment. Air pollution pollutes the air that we breathe which causes health issues. Water pollution degrades the quality of water that we use for drinking purposes. Land pollution results in the degradation of the earth‘s surface as a result of human activities. Noise pollution can cause irreparable damage to our ears when exposed to continuous large sounds like the honking of vehicles on a busy road or machines producing large noise in a factory or a mill.
- **Overpopulation:** Rapid population growth puts a strain on natural resources which results in the degradation of our environment. The mortality rate has gone down due to better medical facilities which have resulted in increased lifespan. More population simply means more demand for food, clothes, and shelter. You need more space to grow food and provide homes to millions of people. This results in deforestation which is another factor of environmental degradation.
- **Landfills:** Landfills pollute the environment and destroy the beauty of the city. Landfills come within the city due to the large amount of waste that gets generated by households, industries, factories, and hospitals. Landfills pose a

great risk to the health of the environment and the people who live there. Landfills produce a foul smell when burned and cause huge environmental degradation.

- **Deforestation:** Deforestation is the cutting down of trees to make way for more homes and industries. Rapid growth in population and urban sprawl are two of the major causes of deforestation. Apart from that, the use of forest land for agriculture, animal grazing, harvest for fuelwood, and logging are some of the other causes of deforestation. Deforestation contributes to global warming as decreased forest size puts carbon back into the environment.
- **Natural Causes:** Things like avalanches, quakes, tidal waves, storms, and wildfires can totally crush nearby animal and plant groups to the point where they can no longer survive in those areas. This can either come to fruition through physical demolition as the result of a specific disaster or by the long term degradation of assets by the presentation of an obtrusive foreign species to the environment. The latter frequently happens after tidal waves, when reptiles and bugs are washed ashore.

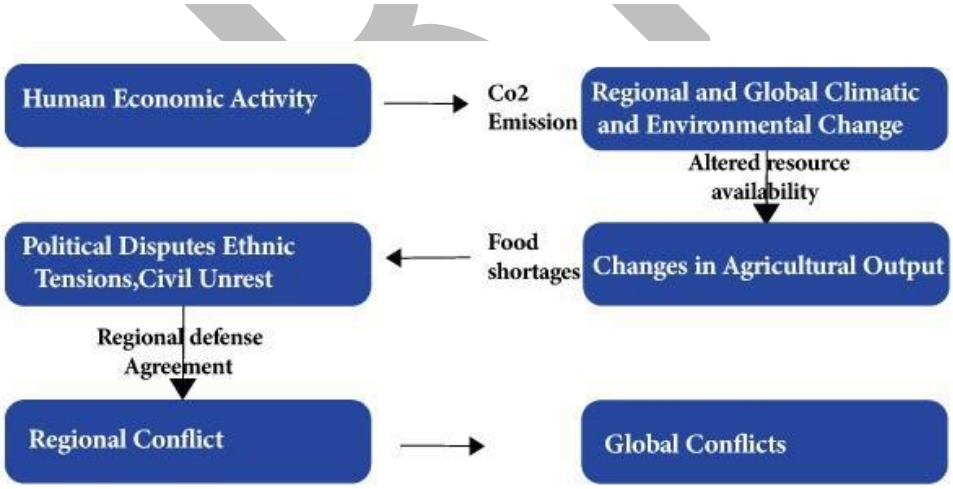
Of course, humans aren't totally to blame for this whole thing. Earth itself causes ecological issues, as well. While environmental degradation is most normally connected with the things that people do, the truth of the matter is that the environment is always changing. With or without the effect of human exercises, a few biological systems degrade to the point where they can't help the life that is supposed to live there.

Effects of Environmental Degradation

- **Impact on Human Health:** Human health might be at the receiving end as a result of environmental degradation. Areas exposed to toxic air pollutants can cause respiratory problems like pneumonia and asthma. Millions of people are known to have died due to the indirect effects of air pollution.
- **Loss of Biodiversity**: Biodiversity is important for maintaining the balance of the ecosystem in the form of combating pollution, restoring nutrients, protecting water sources, and stabilizing climate. Deforestation, global warming,

overpopulation, and pollution are a few of the major causes for the loss of biodiversity.

- **Ozone Layer Depletion:** The ozone layer is responsible for protecting the earth from harmful ultraviolet rays. The presence of chlorofluorocarbons, hydrochlorofluorocarbons in the atmosphere is causing the ozone layer to deplete. As it will deplete, it will emit harmful radiations back to the earth.
- **Loss for Tourism Industry**: The deterioration of the environment can be a huge setback for the tourism industry that relies on tourists for their daily livelihood. Environmental damage in the form of loss of green cover, loss of biodiversity, huge landfills, increased air, and water pollution can be a big turn-off for most of the tourists.
- **Economic Impact:** The huge cost that a country may have to borne due to environmental degradation can have a big economic impact in terms of restoration of green cover, cleaning up of landfills, and protection of endangered species. The economic impact can also be in terms of the loss of the tourism industry.



As you can see, there are a lot of things that can have an effect on the environment. If we are not careful, we can contribute to the environmental degradation that is occurring all around the world.

We can, however, take action to stop it and take care of the world that we live in by providing environmental education to the people which will help them pick familiarity with their surroundings that will enable them to take care of environmental

concerns thus making it more useful and protected for our children and other future generations.

Sustainable Policy Approach to Check Environmental Degradation!

Economic growth always brings risk of environmental damage, as it puts increased pressure on environmental resources. But the policy makers guided by the concept of sustainable development will necessarily work to assure that developing economies remain firmly attached to their ecological roots and these roots are protected so that they may support growth over the long run. Environmental protection is thus inherent in the concept of sustainable development. It describes a process in which natural resource base is not allowed to deteriorate. It emphasizes the role of environmental quality and environmental inputs in the process of raising real income and the quality of life. Thus sustainable development is closely linked to economic development. Sustainable development includes the various policy measures to check the environmental degradation and reduce the costs of economic growth.

1. Reducing Poverty:

Such development projects should be started which provide greater employment opportunities to the poor. The government should expand health and family planning services and education so as to reach the poor that will help reduce population growth. Further, making investments in providing civic amenities like the supply of drinking water, sanitation facilities, alternate habitats in place of slums, etc. will not only improve welfare but also environment.

2. Removing Subsidies:

To reduce environmental degradation at no net financial cost to the government, subsidies for resource use by the private and public sectors should be removed. Subsidies on the use of electricity, fertilizers, pesticides, diesel, petrol, gas, irrigation water, etc. lead to their wasteful use and environmental problems. Subsidies to capital intensive and highly polluting private and public industries lead to environmental degradation. Removing or reducing subsidies will bring both economic and environmental benefits to the country.

3. Clarifying and Extending Property Rights:

Lack of property rights over excessive use of resources leads to degradation of environment. This leads to overgrazing on common or public lands, deforestation, and

over exploitation of minerals, fish, etc. Clarifying and assigning ownership titles and tenurial rights to private owners will solve environmental problems. Places where the use of common lands, forests, irrigation systems, fisheries, etc. are regulated and rules for their proper use are laid down by the community, the ownership rights should be clearly specified in the administrative records.

4. Market Based Approaches:

Besides regulatory measures, there is urgent need for adopting market based approaches for the protection of environment. They aim at pointing to consumers and industries about the costs of using natural resources on environment. These costs are reflected in the prices paid for goods and services so that industries and ultimately the consumers are guided by them to reduce air and water pollution. The Market Based Instruments (MBIs) approach is used in both developed and developing countries. MBIs are of two types: quantity based and piece based. They are in the form of environmental taxes that include "pollution charges (emission tax/pollution taxes), marketable permits, depositor fund system, input taxes/product charges, differential tax rate and user administrative charges and subsidies for pollution abatement equipment for air and water resources."

5. Regulatory Policies:

Regulatory policies also help in reducing environmental degradation. Regulators have to take decisions regarding price, quantity and technology. In making decisions, they have to choose between the quantity or the price of pollution or resources use or technologies. The regulating authority has also to decide whether policies should target the environmental problem directly or indirectly. It lays down technical standards and regulations and charges on air, water and land pollutants. Regulators should be impartial in applying environmental standards to both public and private sector polluters or resources users.

6. Economic Incentives:

Like regulatory policies, economic incentives relate to price, quantity and technology. Incentives are usually in the form of variable fees to resources users for the quantity of pollutants in air, water and land use. They are given rebates if less waste or pollution is generated than the emission standards laid down.

7. Trade Policy:

Trade policy in relation to environment has two implications: first, concerning domestic policy reforms, and second, relating to international trade policy. Domestic trade policy emphasises on the establishment of less polluting industries away from the cities and the use of environmental friendly processes for polluting industries by adopting cleaner technologies. As regards the relation between international trade and environmental quality is concerned, controversy has been going on as to whether liberalised trade causes environmental degradation. The controversy leads to the conclusion that "overall trade liberalisation is likely to produce negative environmental externalities, but also some environmental gains." The former does not imply that free trade should be stopped. Rather, such cost-effective policies should be adopted that optimize externalities. Environmental degradation from free trade should be reduced by strict domestic policy measures based on the "polluter pays principle". It is better to insist on the foreign company to transfer clear technology and assist in cleaning the environment for existing industries.

8. Public Participation:

Public awareness and participation are highly effective to improve environmental conditions. Conducting of formal and informal education programmes relating to environment management and environmental awareness programmes can go a long way in controlling environmental degradation and keeping the environment clean. For instance, the scheme of eco-labelling of products helps consumers to identify products that are environment friendly. In Japan, there are consumer co-operatives that popularise green products which are recyclable, biodegradable, rechargeable, ozone friendly and unleaded. As a further step, firms, industries and other establishments in some countries have to disclose in their Annual Reports the extent to which they are adopting environmental friendly measures. Public participation can also render costless and useful assistance in Afforestation, conservation of wildlife, management of parks, improvements of sanitation and drainage systems and flood control. Use of indigenous institutions and local voluntary organisations can render much help in educating the masses about the harmful effects of environmental degradation and the benefits of keeping the environment clean.

9. Participation in Global Environmental Efforts:

There are many international conventions and agreements on environmental protection and conservation which every country is expected to follow. They include the

Montreal Protocol regarding the phasing out of ozone-depleting chemicals. The Basel Convention which relates to the control of the trans- boundary movement and disposal of hazardous wastes. Among others, there is the Rio Declaration on Environment and Development and the Agenda 21 which is the operational programme for sustainable development. Then, there are the GATT Clauses on Environment. Not all countries are signatories to the various agreements and conventions. There is the threat of trade sanctions against countries that do not honour agreements relating to biodiversity protection or greenhouse gas emissions but many countries do not adhere to them.

Economic significance of environmental degradation

Environmental degradation refers to the deterioration of the natural environment, which can be caused by a range of factors such as pollution, deforestation, overfishing, and climate change. The economic significance of environmental degradation can be seen in a number of ways:

Loss of ecosystem services:

Ecosystem services are the benefits that people obtain from the natural environment, such as clean air and water, fertile soil, and biodiversity. Environmental degradation can lead to a loss of these services, which can have significant economic impacts on industries that rely on them, such as agriculture and tourism.

Increased costs:

Environmental degradation can increase the costs of production for businesses, as they may have to spend more money on pollution control measures or on finding alternative sources of resources. For example, water pollution can increase the cost of water treatment for households and businesses.

Health impacts:

Environmental degradation can have negative impacts on human health, leading to increased healthcare costs and lost productivity. For example, air pollution can lead to respiratory illnesses and increased healthcare costs.

Loss of biodiversity: Environmental degradation can lead to the loss of biodiversity, which can have economic impacts on industries that rely on biological resources, such as pharmaceuticals, forestry, and fisheries.

Climate change:

Environmental degradation can contribute to climate change, which can have significant economic impacts, such as increased frequency and severity of natural disasters, rising sea levels, and changes in temperature and precipitation patterns, which can affect agriculture, tourism, and infrastructure.

Overall, environmental degradation can have significant economic impacts, and it is important for governments, businesses, and individuals to take steps to reduce it and protect the natural environment.

Policy Failures:

Policy failure refers to situations in which government policies or regulations fail to achieve their intended goals or lead to unintended negative consequences. In the context of environmental degradation, policy failure can occur when policies and regulations put in place to protect the environment do not effectively address the problem or result in unintended negative consequences.

There are several reasons why policy failure can occur in the context of environmental degradation:

- **Inadequate regulation:** Government regulations may not be comprehensive or stringent enough to adequately address the problem of environmental degradation. For example, a regulation on industrial waste disposal may not be enforced, resulting in companies dumping waste into rivers or landfills.
- **Regulatory capture:** Regulatory capture occurs when the regulatory agency tasked with enforcing environmental regulations becomes overly influenced by the industry it regulates. This can result in weak enforcement or regulations that favor industry interests over environmental protection.
- **Limited resources:** Governments may not allocate enough resources to enforcing environmental regulations, leading to weak enforcement and noncompliance.
- **Trade-offs with economic growth:** Environmental protection policies may be seen as limiting economic growth, leading policymakers to prioritize economic growth over environmental protection.

- **Inadequate incentives:** Government policies may not provide sufficient incentives for businesses to reduce environmental harm, resulting in a lack of action on environmental protection.
- **International coordination failure:** Environmental problems can be global in nature, and international cooperation is necessary to address them. However, coordination failure can occur when countries fail to cooperate or coordinate their policies, leading to inadequate protection of the environment.

Policy failure in the context of environmental degradation can have significant negative consequences for both the environment and the economy. It is important for policymakers to address the root causes of policy failure and design policies that are effective in protecting the environment and promoting sustainable economic growth.

Market failure

Market failures occur when markets fail to allocate resources efficiently or fail to reflect the true costs of goods or services. In the context of environmental degradation, market failures can occur when the market does not fully take into account the environmental costs of production or consumption. Some examples of market failures in environmental degradation include:

Externalities:

Externalities are costs or benefits that are not reflected in the market price of a good or service. Environmental externalities can occur when the production or consumption of a good or service results in environmental harm that is not accounted for in the price. For example, pollution from a factory can harm the health of nearby residents, but this cost is not reflected in the market price of the goods produced by the factory.

One example is the formula for externalities:

Cost to society = private cost of production + external cost of production

Where the private cost of production represents the cost borne by the producer of the good or service, and the external cost of production represents the environmental harm caused by the production but not borne by the producer. The failure of the market to account for the external cost of production results in an inefficient allocation of resources.

Public goods:

Public goods are goods or services that are non-excludable and non-rivalrous. The environment can be considered a public good because it is difficult to exclude individuals from enjoying its benefits, and one person's use of the environment does not diminish another person's use. However, public goods are often underprovided in the market because individuals may not be willing to pay for them, leading to underinvestment in environmental protection.

Information asymmetry:

Information asymmetry occurs when one party in a transaction has more information than the other party. In the context of environmental degradation, producers may have more information about the environmental impact of their products than consumers, leading consumers to make decisions that do not take into account the environmental costs of production.

Tragedy of the commons:

The tragedy of the commons occurs when individuals act in their own self-interest and consume a shared resource without regard for its long-term sustainability. For example, overfishing can occur when fishermen continue to fish in a shared fishery even when it is clear that the fish population is declining.

Example is the formula for the tragedy of the commons:

Marginal private benefit = marginal social cost

Where the marginal private benefit represents the benefit to the individual of consuming the shared resource, and the marginal social cost represents the cost to society of consuming the shared resource. When the marginal private benefit exceeds the marginal social cost, individuals consume the resource at an unsustainable rate, leading to overuse and depletion of the resource.

Market failures in environmental degradation can have significant negative consequences for the environment and the economy. It is important for policymakers to address market failures through regulatory mechanisms, such as taxes or subsidies, or through the promotion of markets for environmental goods and services, such as carbon markets or payments for ecosystem services.

Causes of market failure

Some of the major causes of market failure are: 1. Incomplete markets, 2. Indivisibilities, 3. Common Property Resources 4. Externalities. In the real world, there is non-attainment of Pareto optimality due to a number of constraints in the working of perfect competition. An important cause of environmental degradation is market failure. It means poor functioning of markets for environmental goods and services. It reflects failure of government policy in removing market distortions created by price controls and subsidies.

Incomplete markets

Markets for certain things are incomplete or missing under perfect competition. The absence of markets for such things as public goods and common property resources is a cause of market failure. There is no way to equate their social and private benefits and costs either in the present or in the future because their markets are incomplete or missing.

Indivisibilities

The Paretian optimality is based on the assumption of complete divisibility of products and factors used in consumption and production. In reality, goods and factors are not infinitely divisible. Rather, they are indivisible. The problem of divisibility arises in the production of those goods and services that are used jointly by more than one person. An important example is of road in a locality. It is used by a number of persons in the locality. But the problem is how to share the costs of repairs and maintenance of the road. In fact, very few persons will be interested in its maintenance. Thus marginal social costs and marginal social benefits will diverge from each other and Pareto optimality will not be achieved.

Common Property Resources

Another cause of market failure is a common property resource. Common ownership when coupled with open access, would also lead to wasteful exploitation in which a user ignores the effects of his action on others. Open access to the commonly owned resources is a crucial ingredient of waste and inefficiency. Its most common example is fish in a lake. Anyone can catch and eat it but no one has an exclusive property right over it. It means that a common property resource is nonexcludable (anyone can use it) and non-rivalrous (no one has an exclusive right over it). The lake is a common property for all fishermen. When a fisherman catches more fish, he reduces

the catch of other fishermen. But he does count this as a cost, yet it is a cost to society. Because the lake is a common property resource where there is no mechanism to restrict entry and to catch fish. The fisherman who catches more fish imposes a negative externality on other fishermen so that the lake is overexploited. This is called the tragedy of the commons which leads to the elimination of social gains due to the overuse of common property. Thus when property rights are common, indefinite or non-existent, social costs will be more than private costs and there will not be Pareto Optimality.

Externalities

Externalities are a key market failure in environmental degradation where the social costs or benefits of economic activity are not fully reflected in the market price, leading to overproduction or overconsumption of goods or services. In the context of environmental degradation, externalities are often negative and result in environmental harm that is not captured by the market.

Types of externalities in environmental degradation include:

Production externalities:

These occur when the production of a good or service creates negative environmental impacts that affect others outside the production process. For example, a factory that emits pollutants into the air or water may harm nearby residents or ecosystems.

Consumption externalities:

These occur when the consumption of a good or service creates negative environmental impacts that affect others outside the consumption process. For example, the use of fossil fuels for transportation may contribute to air pollution and climate change, affecting the health and well-being of others.

Positive externalities:

These occur when the production or consumption of a good or service creates positive environmental impacts that benefit others outside the production or consumption process. For example, the preservation of natural habitats can provide ecosystem services such as water filtration and carbon sequestration, benefiting local communities and society as a whole.

The formula for negative externalities can be expressed as:

Social Cost = Private Cost + External Cost

Where:

Social Cost: the total cost to society of producing a good or service, including the external costs.

Private Cost: the cost incurred by the producer of the good or service, which includes only the direct costs of production.

External Cost:

The cost incurred by third parties that are not involved in the production or consumption of the good or service. In the context of environmental degradation, external costs may include pollution, habitat destruction, and other environmental harm.

Addressing externalities in environmental degradation requires policies that internalize the external costs, such as taxes or regulations that incentivize producers to reduce pollution or other environmental harm. Alternatively, markets for environmental goods and services can create economic incentives for sustainable production and consumption, by valuing ecosystem services and encouraging sustainable practices.

The Coase theorem

The Coase theorem can be applied to environmental degradation and the problem of externalities. The theorem suggests that if property rights are well-defined

and transaction costs are low, the parties involved in an externality dispute can negotiate a solution that is mutually beneficial, without the need for government intervention.

For example, consider a situation where a factory is emitting pollution that is harming a nearby residential community. The Coase theorem suggests that the factory owner and the affected residents could negotiate a solution that maximizes overall welfare. This could involve the factory owner paying compensation to the residents, or the residents accepting the pollution in exchange for some other form of compensation or benefit.

However, the applicability of the Coase theorem in environmental degradation is limited by several factors. In reality, it can be difficult to define property rights in a way that accurately reflects the complexity of environmental resources, and transaction costs may be high, making it difficult for parties to negotiate a mutually beneficial solution. Additionally, in cases where externalities affect large groups of people or future generations, it may be difficult to identify and negotiate with all the parties involved.

Furthermore, the Coase theorem assumes that all parties have perfect information and act rationally to maximize their own welfare. In reality, this may not always be the case, and parties may act in ways that are not conducive to efficient outcomes.

Therefore, while the Coase theorem offers a useful framework for thinking about externalities and environmental degradation, it is not a panacea, and government intervention may still be necessary to address environmental externalities and achieve efficient outcomes.

Economic analysis of environmental degradation

Economic analysis of environmental degradation involves assessing the costs and benefits of environmental policies and activities, taking into account their impacts on economic growth, human welfare, and the natural environment. One of the key methods used in economic analysis of environmental degradation is cost-benefit analysis (CBA).

Cost-benefit analysis involves comparing the costs and benefits of an environmental policy or activity over a specified time period. The costs may include the direct costs of implementing the policy or activity, as well as any indirect costs such as lost economic opportunities or changes in behavior. The benefits may include the value of improved environmental quality, such as cleaner air or water, as well as any economic benefits that result from the policy or activity, such as increased tourism or reduced healthcare costs.

The formula for cost-benefit analysis is as follows:

Net Benefits = Total Benefits – Total Costs

Where:

Total Benefits = the sum of all benefits resulting from the policy or activity, measured in monetary terms.

Total Costs = the sum of all costs associated with the policy or activity, measured in monetary terms.

Net Benefits = the difference between total benefits and total costs, also measured in monetary terms.

If the net benefits are positive, the policy or activity is considered economically efficient and should be implemented. If the net benefits are negative, the policy or activity should not be implemented.

Overall, economic analysis of environmental degradation helps decision-makers evaluate the trade-offs between economic growth and environmental protection, and make informed decisions about how to balance these competing priorities.

There are several types of economic analysis that can be used to assess environmental degradation, including:

Cost-Benefit Analysis (CBA): CBA is the most commonly used method for economic analysis of environmental degradation. It compares the costs of environmental

degradation or protection against the benefits that accrue from these actions, taking into account both monetary and non-monetary factors.

Cost-Effectiveness Analysis (CEA): CEA compares the costs of achieving a specific environmental goal with different policy options. It does not consider the overall benefits of the policy but only focuses on the costs of achieving the desired outcome.

Input-Output Analysis: Input-output analysis is a technique used to examine the linkages between different sectors of the economy and their impacts on the environment. It helps to identify the sources of environmental degradation and the economic sectors that contribute most to this degradation.

Environmental Impact Assessment (EIA): EIA is a systematic process used to identify and evaluate the potential environmental impacts of a project or policy. It considers the direct and indirect impacts on the environment and how these impacts will affect economic and social systems.

Life Cycle Assessment (LCA): LCA evaluates the environmental impacts of a product, service, or process throughout its entire life cycle. It considers the raw materials used, manufacturing processes, transportation, use, and disposal of the product, and how these stages affect the environment and the economy.

Each of these methods has its own strengths and weaknesses, and the choice of method will depend on the specific objectives of the analysis and the availability of data. In practice, a combination of these methods is often used to provide a more comprehensive understanding of the economic impacts of environmental degradation or protection.

Equi-marginal principle:

The equi-marginal principle is a concept used in economics to determine the optimal allocation of resources among different activities or sectors. It states that resources should be allocated in such a way that the marginal benefit of each activity or sector is equal to its marginal cost.

In the context of environmental degradation, the equi-marginal principle can be used to determine the optimal level of pollution or environmental protection across different activities or sectors. For example, suppose a company is considering two different production methods that have different environmental impacts. Production method A has a lower environmental impact but a higher cost than production method B, which has a higher environmental impact but a lower cost. The equi-marginal principle can be used to determine the optimal level of environmental protection or degradation for the company.

The formula for the equi-marginal principle is:

Marginal Benefit (MB) = Marginal Cost (MC)

Where:

Marginal Benefit (MB) refers to the additional benefit gained from a unit increase in an activity or sector.

Marginal Cost (MC) refers to the additional cost incurred from a unit increase in an activity or sector

Types of Equi-Marginal Principle:

Production: In the context of production, the equi-marginal principle refers to the allocation of resources among different inputs in order to maximize output. This principle can be used to determine the optimal combination of inputs, such as labor and capital, to produce a given level of output.

Consumption: In the context of consumption, the equi-marginal principle refers to the allocation of a consumer's budget among different goods and services in order to maximize their satisfaction or utility. This principle can be used to determine the optimal combination of goods and services to consume given a fixed budget.

Investment: In the context of investment, the equi-marginal principle refers to the allocation of a portfolio among different assets in order to maximize the expected return

while minimizing risk. This principle can be used to determine the optimal combination of assets, such as stocks and bonds, in a portfolio.

Overall, the equi-marginal principle is a useful tool in economics for making decisions about how to allocate resources among different activities or sectors. By balancing the marginal benefits and costs of each activity or sector, it can help to maximize overall utility or benefit.

UNIT-III

Economics of pollution

Economics of pollution refers to the study of how pollution affects the economy and how economic incentives and policies can be used to reduce pollution.

Pollution can have significant economic costs, including health impacts, damage to ecosystems and natural resources, and reduced productivity. The costs of pollution can be both direct, such as healthcare costs and property damage, and indirect, such as lost income and reduced quality of life.

One approach to reducing pollution is to use economic incentives, such as taxes, subsidies, and cap-and-trade systems. For example, a tax on carbon emissions can create an economic incentive for companies to reduce their carbon footprint and invest in cleaner technologies. Similarly, a cap-and-trade system can set a limit on the amount of pollution that companies can emit, while allowing them to trade pollution permits among themselves to achieve the most efficient use of resources.

Another approach is to use regulations, such as emissions standards, to require companies to reduce their pollution levels. However, regulations can be costly and may not always be the most efficient way to achieve pollution reduction.

In addition to policies aimed at reducing pollution, there is also a growing interest in the concept of a circular economy, which aims to minimize waste and pollution by reusing and recycling materials. This approach can create economic benefits by reducing the need for new raw materials and decreasing waste disposal costs.

Overall, the economics of pollution highlights the need for a careful balance between environmental protection and economic growth. By using economic incentives and policies to reduce pollution, it is possible to achieve a more sustainable and prosperous future.

The economics of pollution encompasses different types of pollution, and the economic analysis and policies used to address them. Here are some common types of pollution and their associated economic considerations:

Air pollution: Air pollution results from emissions from transportation, industry, and power generation. The economic costs of air pollution include healthcare costs, reduced worker productivity, and damage to ecosystems. Economic policies such as taxes on emissions or tradable permit systems can be used to reduce air pollution.

Water pollution: Water pollution results from agricultural runoff, industrial discharges, and wastewater treatment plants. Economic costs include health impacts from contaminated drinking water, damage to fisheries, and tourism losses. Policies such as water quality standards or pollution taxes can help reduce water pollution.

Land pollution: Land pollution can result from solid waste disposal, hazardous waste disposal, and industrial contamination. The economic costs include damage to soil and water quality, lost property values, and health impacts. Policies such as regulations on waste disposal, fees on waste disposal, and remediation requirements can help reduce land pollution.

Noise pollution: Noise pollution can result from transportation, industrial activity, and construction. The economic costs include health impacts such as hearing loss and sleep disturbance, reduced property values, and reduced tourism. Policies such as noise regulations and fees on noise-producing activities can help reduce noise pollution.

Light pollution: Light pollution results from excessive outdoor lighting, which can cause sleep disturbance and disrupt ecosystems. Economic costs include health impacts, energy waste, and reduced tourism. Policies such as lighting regulations and fees on excessive lighting can help reduce light pollution.

Overall, the economics of pollution highlights the need for a careful balance between economic growth and environmental protection. By using economic analysis and policies to reduce pollution, it is possible to achieve a more sustainable and prosperous future.

Optimal pollution:

The concept of optimal pollution refers to the idea that there is an optimal level of pollution that balances the benefits of economic growth with the costs of pollution reduction. In other words, it suggests that there is a level of pollution that is socially optimal and provides the greatest net benefit to society.

The optimal level of pollution can be determined using economic analysis, which compares the costs and benefits of pollution reduction measures. On the cost side, this analysis would consider the costs of reducing pollution, such as investments in clean technologies or the economic impact of reduced economic growth. On the benefit side, it would consider the benefits of reducing pollution, such as improved public health, increased productivity, and reduced environmental damage.

The optimal level of pollution can vary depending on a variety of factors, including the type of pollution, the economic conditions of the region, and the preferences of society. For example, the optimal level of pollution for a developing country may be higher than that of a developed country, as the benefits of economic growth may outweigh the costs of pollution reduction in the short term.

While the concept of optimal pollution can be controversial, it is often used in environmental policy to inform decisions about pollution reduction measures. For example, policymakers may use economic analysis to determine the optimal level of pollution for a particular region or industry and use this information to design policies that balance environmental protection with economic growth.

Overall, the concept of optimal pollution highlights the need for a careful balance between economic growth and environmental protection. By identifying the optimal level of pollution, policymakers can make informed decisions that promote sustainable development and ensure the greatest net benefit to society.

There are different types of optimal pollution, depending on the type of pollution and the context in which it is being considered. Here are some examples:

Carbon emissions: One of the most common types of optimal pollution is related to carbon emissions, which contribute to climate change. The optimal level of carbon emissions depends on a variety of factors, including the expected costs of climate change and the costs of reducing emissions through measures such as carbon taxes or cap-and-trade systems.

Air pollution: The optimal level of air pollution is determined by the trade-off between the benefits of economic growth and the costs of public health impacts. For example, policymakers may consider the costs of reducing air pollution through regulations or investments in cleaner technologies, as well as the benefits of reduced healthcare costs and increased productivity.

Water pollution: The optimal level of water pollution is determined by the trade-off between the benefits of economic activities such as agriculture or industry and the costs of environmental damage and public health impacts. For example, policymakers may consider the costs of reducing water pollution through regulations or investments in pollution control technologies, as well as the benefits of improved water quality and reduced healthcare costs.

Waste pollution: The optimal level of waste pollution is determined by the trade-off between the benefits of economic activities and the costs of waste disposal and environmental damage. For example, policymakers may consider the costs of reducing waste pollution through measures such as recycling programs or investments in waste-to-energy technologies, as well as the benefits of reduced landfill use and reduced environmental damage.

Overall, the concept of optimal pollution applies to any type of pollution where there is a trade-off between the benefits of economic growth and the costs of environmental damage and public health impacts. By identifying the optimal level of pollution, policymakers can make informed decisions that balance economic development with environmental protection.

Economic pollution regulation and its types:

Economic pollution regulation refers to the use of economic policies and incentives to regulate pollution and environmental degradation. Here are some common types of economic pollution regulations:

Command and control regulations: These regulations set specific limits on the amount of pollution that is allowed, and require businesses to use certain technologies or practices to reduce their emissions. Examples of command and control regulations include limits on emissions of sulfur dioxide from power plants or requirements for industries to install pollution control equipment.

Market-based mechanisms: Market-based mechanisms such as cap-and-trade systems and pollution taxes provide economic incentives for businesses to reduce their pollution. In a cap-and-trade system, the government sets a limit on the amount of pollution that is allowed and issues permits that allow businesses to emit a certain amount of pollutants. Businesses that emit less than their allotted amount can sell their permits to other businesses, providing a financial incentive to reduce emissions. Pollution taxes put a price on each unit of pollution emitted, providing an incentive for businesses to reduce emissions to avoid the tax.

Voluntary agreements: Voluntary agreements are agreements between the government and businesses or industries to voluntarily reduce their emissions or improve their environmental practices. These agreements are often negotiated between the parties and can provide more flexibility than command and control regulations.

Information-based regulations: Information-based regulations provide consumers with information about the environmental impact of the products they purchase. Examples of information-based regulations include labels on appliances that indicate their energy efficiency or requirements for companies to report their greenhouse gas emissions.

Overall, economic pollution regulations aim to reduce the environmental impact of human activities by providing economic incentives to reduce pollution. By using a combination of regulatory approaches, it is possible to achieve a more sustainable and environmentally friendly economy.

Economic pollution regulations monitoring and enforcement:

Effective monitoring and enforcement are crucial for ensuring that economic pollution regulations are being followed and that they are effective in reducing pollution. Here are some key aspects of monitoring and enforcement in economic pollution regulation:

Emissions monitoring: Emissions monitoring involves measuring the amount of pollutants that are emitted from regulated sources, such as factories or power plants. This can be done using instruments such as smokestack monitors, continuous emissions monitoring systems, or ambient air quality monitors.

Compliance monitoring: Compliance monitoring involves checking that regulated entities are following the regulations and requirements that have been set for them. This can involve regular inspections of facilities, audits of records and reports, or spot checks to ensure that equipment is functioning properly.

Enforcement actions: When non-compliance is identified, enforcement actions may be taken to ensure that the regulated entity comes back into compliance. Enforcement actions can range from warning letters or fines to permit revocations or legal action.

Incentives for compliance: In addition to enforcement actions, incentives for compliance can also be used to encourage regulated entities to follow regulations. For example, businesses that go beyond regulatory requirements to reduce their pollution levels could be rewarded with tax credits or other incentives.

Transparency: Transparency in the regulatory process is important to build public trust in the regulatory system. This can involve making emissions data and compliance information publicly available, holding public hearings or comment periods on proposed regulations, and ensuring that regulatory agencies are accountable to the public.

Performance monitoring: Performance monitoring involves evaluating the effectiveness of the regulatory system as a whole. This can involve assessing whether the regulations are achieving their intended outcomes, such as reducing pollution levels, and identifying areas where improvements could be made.

Overall, monitoring is an essential component of economic pollution regulation. It helps ensure that regulations are being followed, promotes compliance with regulations, and provides feedback on the effectiveness of regulatory policies

Managing pollution using existing markets:

One approach to managing pollution is through the use of existing markets, such as the market for emissions trading or the market for renewable energy certificates. Here are some types of market-based approaches for managing pollution, along with their formulas and graphs:

Pollution taxes: A pollution tax is a fee imposed on polluters for each unit of pollution they emit. The tax is designed to increase the cost of pollution to the polluter, which provides an incentive for them to reduce their pollution levels. The optimal level of pollution occurs where the marginal cost of pollution reduction is equal to the marginal benefit of pollution reduction.

Formula: MC pollution reduction = MB pollution reduction

Emissions trading: Emissions trading is a market-based approach in which a cap is placed on the total amount of emissions that are allowed in a particular industry or region. Companies are then issued permits, or allowances, that allow them to emit a certain amount of pollution. If a company emits less pollution than its allotted permits, it can sell the excess permits to other companies that need to emit more pollution. The price of the permits is determined by the market, and companies that emit more pollution than their allotted permits can purchase additional permits to cover their excess emissions. The formula for emissions trading is:

Emissions = (Number of permits) x (Emissions per permit)

The graph for emissions trading shows a downward-sloping demand curve for permits, and an upward-sloping supply curve, with the equilibrium price determined by the intersection of the two curves.

Renewable energy certificates (RECs): RECs are a market-based approach to incentivize the use of renewable energy sources. A REC represents proof that a certain amount of renewable energy has been generated and fed into the electrical grid. Companies can purchase RECs to offset their use of non-renewable energy sources, and the price of RECs is determined by supply and demand in the market. The formula for RECs is:

Renewable energy generation = (Number of RECs) x (Amount of renewable energy per REC)

The graph for RECs shows a downward-sloping demand curve for RECs, and an upward-sloping supply curve, with the equilibrium price determined by the intersection of the two curves.

Overall, market-based approaches to managing pollution can be effective in reducing pollution levels while also providing economic incentives for companies to invest in clean technologies and practices.

Bargaining solutions:

Economic pollution" refers to the negative externalities that arise from economic activity, such as pollution, congestion, and noise. Bargaining solutions, also known as cooperative game theory, are a type of solution that addresses the problem of how to distribute the gains from cooperation among multiple players.

In the context of economic pollution, bargaining solutions can be used to address the problem of how to allocate the costs of pollution among the affected parties. One approach is to use a cooperative game-theoretic framework to model the interactions between the polluters and the affected parties, and to find a solution that maximizes the total gains from cooperation. Here are some types of bargaining solutions that can be applied to the problem of economic pollution:

Nash bargaining solution: This solution is based on the idea that the parties involved will agree to a solution that gives them each a fair share of the gains from cooperation. In the context of economic pollution, the parties might agree to a solution that distributes the costs of pollution in a way that reflects the amount of harm suffered by each party.

Kalai-Smorodinsky bargaining solution: This solution attempts to find a compromise between the positions of the parties involved by finding a point on a line between the two parties' ideal outcomes that is equidistant from each party's ideal outcome. In the context of economic pollution, the parties might agree to a solution that distributes the costs of pollution in a way that is midway between the parties' ideal outcomes.

Constrained bargaining solution: This solution takes into account any constraints or limitations on the bargaining process, such as legal or political constraints, and attempts to find a solution that satisfies these constraints while maximizing the gains from cooperation. In the context of economic pollution, the parties might agree to a solution that meets certain legal or regulatory requirements while minimizing the costs of pollution.

Cooperative game theory: This approach considers the situation as a cooperative game, where the parties involved can cooperate to achieve a common goal. The solution can then be found by dividing the gains from cooperation among the parties in a fair and efficient way. In the context of economic pollution, the parties might agree to a solution that distributes the costs of pollution in a way that reflects the parties' contributions to the pollution problem.

Overall, the choice of bargaining solution will depend on the specific context of the economic pollution problem, as well as the preferences and constraints of the parties involved.

Managing pollution through market intervention:

Market interventions can be an effective way to manage pollution by providing economic incentives and disincentives to reduce pollution. Here are some types of market interventions that can be used:

Pollution taxes or fees:

These are taxes or fees imposed on polluting activities or emissions. By increasing the cost of polluting, this can encourage individuals and firms to reduce pollution by investing in cleaner technologies, reducing energy consumption or finding more sustainable ways to do business.

This is a direct tax on pollution that is proportional to the amount of pollution emitted. For example, a tax of $10 per ton of CO2 emissions from power plants.

Equation: Pollution tax = (Pollution emitted) x (Tax rate per unit of pollution)

Example: A steel company emits 1,000 tons of pollutants into the air. The government imposes a tax of $50 per ton of pollution emitted. The total pollution tax that the company has to pay is:

Pollution tax = 1,000 x $50 = $50,000

Cap and trade systems:

This is a market-based approach where a cap is placed on the total amount of pollution allowed in a given area, and companies are then issued permits that allow them to pollute a certain amount. If a company needs to exceed their permit allowance, they can buy permits from other companies that have not used up their allowance. This creates a market for pollution allowances, and encourages companies to find ways to reduce their pollution levels in order to sell any surplus permits for profit.

In a cap and trade system, a cap is placed on the total amount of pollution allowed in a given area. Companies are then issued permits that allow them to pollute a certain amount. If a company needs to exceed their permit allowance, they can buy permits from other companies that have not used up their allowance.

Equation: Total pollution allowed = (Number of permits issued) x (Pollution allowance per permit)

Example: In a cap and trade system, 100 permits are issued to power plants in a certain region. Each permit allows the plant to emit 10 tons of CO2. The total pollution allowed in the region is:

$$\text{Total pollution allowed} = 100 \times 10 = 1{,}000 \text{ tons of } CO_2$$

If a power plant emits 12 tons of CO2, they will need to purchase 2 extra permits from other power plants in the region.

Subsidies:

Governments can offer subsidies to firms or individuals who invest in environmentally friendly technologies or practices. This provides a financial incentive for companies to invest in cleaner technologies, which can reduce pollution levels.

Governments can offer subsidies to firms or individuals who invest in environmentally friendly technologies or practices. For example, a subsidy of $500 per electric car purchased.

Equation: Subsidy = (Amount of investment in environmentally friendly technology) x (Subsidy rate)

Example: A company invests $10,000 in solar panels to power their factory. The government offers a subsidy of 20% on investments in renewable energy technologies. The total subsidy that the company is eligible for is:

$$\text{Subsidy} = \$10{,}000 \times 0.20 = \$2{,}000$$

Tradable permits:

This is similar to cap and trade systems, but permits are tradable between firms. This means that firms that can reduce their emissions below the required level can sell their permits to other firms that are struggling to meet the cap. Tradable permits provide a financial incentive for companies to invest in cleaner technologies, as well as encouraging firms to trade permits in order to achieve the required pollution reductions.

In a tradable permit system, permits are issued to firms that allow them to pollute up to a certain amount. Firms can then buy or sell these permits on a market, providing a financial incentive for firms to reduce their pollution levels.

Equation: Total pollution allowed = (Number of permits issued) x (Pollution allowance per permit)

Example: In a tradable permit system, 500 permits are issued to power plants in a certain region. Each permit allows the plant to emit 10 tons of CO2. The total pollution allowed in the region is:

Total pollution allowed = 500 x 10 = 5,000 tons of CO2

If a power plant emits only 8 tons of CO2, they have 2 extra permits that they can sell to other power plants in the region.

Green taxes:

This is a tax on goods and services that have a negative impact on the environment. The aim is to make polluting goods and services more expensive and encourage people to use environmentally friendly alternatives. For example, a tax on single-use plastic bags could encourage people to use reusable bags.

Overall, market interventions can be a powerful tool in managing pollution by providing financial incentives to reduce pollution levels. However, it's important to carefully design these interventions to ensure they are effective and fair for all stakeholders.

This is a tax on goods and services that have a negative impact on the environment. For example, a tax of $0.10 on each single-use plastic bag.

Equation: Green tax = (Amount of goods or services sold) x (Tax rate per unit)

Example: A supermarket sells 10,000 single-use plastic bags. The government imposes a green tax of $0.10 per bag. The total green tax that the supermarket has to pay is:

Green tax = 10,000 x $0.10 = $1,000

Tradable permits:

In a tradable permit system, permits are issued to firms that allow them to pollute up to a certain amount. Firms can then buy or sell these permits on a market, providing a financial incentive for firms to reduce their pollution levels.

UNIT-IV

COST BENEFIT ANALYSIS

In environmental economics, cost-benefit analysis (CBA) is a tool used to evaluate the economic efficiency of environmental policies or projects. It involves comparing the costs and benefits of different environmental policy options to determine which one is the most cost-effective and efficient.

CBA in environmental economics takes into account the externalities associated with environmental policies or projects. Externalities refer to the costs or benefits that are not directly reflected in the market prices. For example, environmental pollution caused by a manufacturing plant may not be reflected in the cost of its products.

The CBA process in environmental economics involves identifying all the costs and benefits associated with the policy or project, including direct costs (such as implementation costs and compliance costs) and indirect costs (such as health and environmental impacts). The benefits can include both market and non-market benefits, such as improved air quality, reduced greenhouse gas emissions, and improved human health.

The results of the CBA can be used to inform decision-making and policy development in the field of environmental economics, with the goal of achieving the most efficient and cost-effective environmental outcomes.

ECONOMIC VALUE OF ENVIRONMENTAL RESOURCES:

The economic value of environmental resources refers to the monetary or non-monetary benefits that individuals, society, or the economy derive from the natural environment. There are several types of economic value associated with environmental resources, including:

Direct Use Value: This type of economic value refers to the economic benefits derived from the direct use of environmental resources. Examples of direct use value include:

- Timber harvesting: the value derived from the extraction and sale of timber from forests for commercial use.
- Fishing: the value derived from the capture and sale of fish from oceans, rivers, or lakes for commercial or recreational purposes.
- Recreation: the value derived from the use of environmental resources for leisure activities, such as camping, hiking, or wildlife watching.

Indirect Use Value: This type of economic value refers to the economic benefits derived from the indirect benefits of environmental resources. Examples of indirect use value include:

- Carbon sequestration: the value derived from the ability of forests, wetlands, and other ecosystems to capture and store carbon, thereby mitigating climate change and reducing the costs of carbon emissions.
- Watershed protection: the value derived from the ability of forests, wetlands, and other ecosystems to regulate water quality and quantity, thereby reducing the costs of water treatment and flooding.
- Biodiversity: the value derived from the variety of plant and animal species and their ecosystems, which provide benefits such as genetic resources, medicines, and ecosystem services.

Option Value: This type of economic value refers to the economic benefits derived from preserving environmental resources for potential future use or benefits. Examples of option value include:

- Preservation of natural habitats: the value derived from preserving natural habitats that may contain undiscovered or underutilized resources or provide future opportunities for research or recreation.

Preservation of historical landmarks: the value derived from preserving historical landmarks or cultural sites that may provide future opportunities for education, tourism, or cultural enrichment.

Existence Value: This type of economic value refers to the economic benefits derived from the existence of environmental resources, regardless of whether they are used or not. Examples of existence value include:

- The value that individuals place on the existence of endangered or rare species, such as elephants or pandas.
- The value that individuals place on the preservation of natural landscapes, such as mountains or oceans.

Bequest Value: This type of economic value refers to the economic benefits derived from preserving environmental resources for future generations. Examples of bequest value include:

- The value that individuals place on preserving natural resources for their children or grandchildren.
- The value that individuals place on preserving cultural or historical landmarks for future generations to appreciate and learn from.

MESEURING OF ECONOMIC VALUES:

There are several ways to measure the economic value of environmental resources. Here are a few examples:

Total Economic Value (TEV) Equation:

This equation takes into account all the possible economic values associated with an environmental resource, including direct use value, indirect use value, option value, existence value, and bequest value. The equation is expressed as follows:

$$TEV = VU + VI + VO + VE + VB$$

Where:

VU = Direct Use Value: the value derived from the direct use of the resource, such as timber harvesting or recreation.

VI = Indirect Use Value: the value derived from the resource's indirect benefits, such as carbon sequestration or biodiversity.

VO = Option Value: the value of preserving the resource for future use or potential benefits.

VE = Existence Value: the value that individuals place on the mere existence of the resource, regardless of whether they use it or not.

VB = Bequest Value: the value that individuals place on preserving the resource for future generations.

Willingness-to-Pay (WTP) Equation:

This equation measures the economic value of an environmental resource by estimating the maximum amount of money that individuals are willing to pay to obtain or preserve it. The equation is expressed as follows:

$$WTP = \Delta U / \Delta P$$

Where:

ΔU = Change in Utility: the change in satisfaction or well-being that individuals derive from obtaining or preserving the resource.

ΔP = Change in Price: the change in the price that individuals are willing to pay for the resource.

Replacement Cost Equation:

This equation measures the economic value of an environmental resource by estimating the cost of replacing it if it were to be lost or degraded. The equation is expressed as follows:

$$RC = C + D + S + P$$

Where:

C = Capital Cost: the cost of constructing or developing a substitute for the resource.

D = Development Cost: the cost of developing the substitute resource to a level that is comparable to the original resource.

S = Supply Cost: the cost of supplying the substitute resource to meet the same level of demand as the original resource.

P = Price Premium: the premium that individuals are willing to pay for the original resource over the substitute resource.

ENVIRONMENTAL DAMAGE:

Environmental damage refers to the harm or destruction of natural resources or ecosystems, either by human activities or natural disasters. Environmental damage can occur at local, regional, or global levels and can have significant negative impacts on the environment, society, and the economy.

Human activities such as industrial production, transportation, urbanization, and agriculture can cause environmental damage by releasing pollutants, emitting greenhouse gases, and destroying habitats. Examples of environmental damage caused by human activities include deforestation, soil erosion, air and water pollution, and climate change.

Natural disasters such as earthquakes, floods, and wildfires can also cause environmental damage by destroying habitats, polluting waterways, and releasing greenhouse gases. However, unlike human-caused environmental damage, natural disasters are not preventable but their effects can be mitigated through preparedness, response, and recovery efforts.

Environmental damage can have severe consequences, including loss of biodiversity, soil degradation, water scarcity, food insecurity, and public health risks. Therefore, efforts to prevent or reduce environmental damage are critical for sustainable development and the well-being of current and future generations

CAUSES:

The causes of environmental damage are often related to human activities, such as industrial production, transportation, urbanization, and agriculture. Examples of causes of environmental damage include:

- Overconsumption of natural resources, leading to depletion and waste
- Unsustainable agricultural practices, leading to soil degradation and pollution
- Deforestation, leading to habitat loss and carbon emissions
- Industrial production, leading to air and water pollution

- Transportation, leading to air pollution and greenhouse gas emissions
- Urbanization, leading to habitat loss and soil degradation

Efforts to prevent or reduce environmental damage require collective action, including government regulations, private sector initiatives, and individual choices. Examples of such efforts include renewable energy production, sustainable agriculture practices, and conservation efforts to protect natural habitats and biodiversity.

CONCEPT OF TOTAL ECONOMIC VALUE (TEV):

The concept of total economic value (TEV) is used to estimate the comprehensive economic value of a particular environmental resource or ecosystem. The TEV approach takes into account both the direct and indirect use values, as well as non-use values, of an environmental resource or ecosystem. The following are examples of each type of TEV:

Use Value:

This refers to the direct and indirect economic benefits that humans derive from an environmental resource or ecosystem, such as food, fiber, timber, water, and recreation. For example:

- Commercial fishing is a use value of marine ecosystems, as it provides an important source of protein and income for millions of people around the world.
- The use of forests for timber and wood products is another example of use value.

Option Value:

This refers to the value people place on the potential future use of an environmental resource or ecosystem, even if they do not currently use or plan to use it. For example:

- Preserving the Amazon rainforest has an option value for future scientific research, medicinal discoveries, and potential ecotourism.
- Protecting coral reefs has an option value for future marine biodiversity, potential bioprospecting, and aesthetic values.

Existence Value:

This refers to the value people place on the mere existence of an environmental resource or ecosystem, regardless of any direct or indirect use. For example:

- The existence of endangered species such as the giant panda, which has a significant cultural and symbolic value, is an example of existence value.
- The Grand Canyon has an existence value due to its natural beauty and importance as a geological formation.

Bequest Value:

This refers to the value people place on preserving an environmental resource or ecosystem for future generations to use and enjoy. For example:

- The Great Barrier Reef has a bequest value as it is important to preserve the reef for future generations to appreciate and benefit from its ecological, economic, and cultural values.
- National parks and other protected areas also have a bequest value as they provide important natural habitats and recreational opportunities for future generations.

Cultural Value: This refers to the value people place on an environmental resource or ecosystem due to its cultural significance, such as historical sites or sacred landscapes. For example:

- Uluru in Australia has a cultural value as a sacred site for Indigenous Australians and is also a popular tourist attraction.
- Machu Picchu in Peru has a cultural value as an archaeological site and a popular tourist destination.

Estimating the total economic value of an environmental resource or ecosystem is important for decision-making and policy-making processes. By including all of the different types of economic values, policymakers can make more informed decisions about how to manage and protect these resources for both current and future generations.

ALTERNATIVE APPROACHES TO VALUATION:

We know that concept of total economic value (TEV) is used to estimate the comprehensive economic value of a particular environmental resource or ecosystem. The TEV approach takes into account both the direct and indirect use values, as well as non-use values, of an environmental resource or ecosystem. However, there are also alternative approaches to valuation that can be used to estimate the economic value of environmental resources.

Revealed preference method:

This method involves observing the actual market behavior of consumers to determine their willingness to pay for a particular environmental resource or ecosystem.

For example, the travel cost method looks at the costs incurred by tourists to visit a national park, and uses this information to estimate the value of the park.

Stated preference method:

This method involves asking people directly about their preferences and willingness to pay for a particular environmental resource or ecosystem.

For example, a survey may ask people how much they would be willing to pay to preserve a particular wetland or to prevent the extinction of a particular species.

Hedonic pricing method:

This method involves analyzing the price of a good or service in relation to its characteristics, including environmental quality.

For example, the hedonic pricing method could be used to estimate the value of clean air by analyzing the prices of homes in different areas with different levels of air pollution.

Cost-based method:

This method involves estimating the costs that would be incurred if the environmental resource or ecosystem were lost, damaged or degraded.

For example, the cost-based method could be used to estimate the economic value of wetlands by analyzing the costs associated with water purification or flood protection services provided by wetlands.

Each approach has its own strengths and weaknesses, and the most appropriate method will depend on the particular environmental resource or ecosystem being valued, as well as the available data and resources. By using multiple approaches and comparing the results, policymakers can make more informed decisions about how to manage and protect environmental resources for both current and future generations.

COST-BENEFIT ANALYSIS (CBA) AND DISCOUNTING

Cost-benefit analysis (CBA) is a method used to evaluate the economic feasibility of a particular project or policy by comparing the costs of the project or policy with its expected benefits. Discounting is a technique used in CBA to adjust future costs and benefits to their present value. The following are types of discounting and examples of how they can be used in CBA:

Constant discount rate:

This involves applying a fixed discount rate to all future costs and benefits.

For example, if the discount rate is 5%, a future cost or benefit of $100 in one year would be discounted to a present value of $95.24.

Declining discount rate:

This involves applying a decreasing discount rate to future costs and benefits. The idea behind this approach is that the value of future costs and benefits decreases over time as uncertainty about the future increases.

For example, a declining discount rate might start at 5% and decrease by 0.5% each year.

Hyperbolic discounting:

This approach acknowledges that people tend to have a stronger preference for immediate rewards over future rewards, and as a result, discounts future benefits and costs more heavily than constant or declining discount rates.

For example, an individual may value receiving $100 today more than receiving $110 in a year, even if the discount rate is relatively low.

Examples of how these discounting types can be used in CBA include:

- A government is considering building a new highway. The cost of building the highway is $10 million, and it is expected to generate benefits of $5 million per year for the next 20 years. Using a constant discount rate of 5%, the present value of the benefits would be $61 million, which is greater than the cost, indicating that the project is economically feasible.
- An organization is considering investing in a new solar panel installation. The cost of the installation is $100,000, and it is expected to generate savings of $20,000 per year for the next 10 years. Using a declining discount rate, the present value of the benefits would be $145,000, which is greater than the cost, indicating that the investment is economically feasible.
- A company is considering implementing a new recycling program. The cost of the program is $50,000, and it is expected to generate savings of $10,000 per year for the next 5 years. Using hyperbolic discounting, the present value of the benefits would be lower than using a constant or declining discount rate, indicating that the investment may not be economically feasible.

UNIT-V

ECONOMICS OF BIODIVERSITY

The economics of biodiversity refers to the study of the economic value and impacts of biodiversity, which is the variety of life forms on Earth, including plants, animals, and microorganisms. It focuses on understanding the interrelationship between biodiversity and economic activities, and how changes in biodiversity can affect economic systems and human well-being.

Biodiversity provides numerous ecosystem services that are vital for human societies, such as food production, water purification, climate regulation, and recreational opportunities. These services have economic value and contribute to economic development and human welfare. At the same time, economic activities, such as habitat destruction, pollution, and overexploitation of natural resources, can have negative impacts on biodiversity.

There are different types of economics of biodiversity, each with its own focus and approach. Here are three main types:

Economic Valuation: This type of economics of biodiversity aims to assign monetary values to the goods and services provided by biodiversity. It involves assessing the economic benefits of preserving and conserving biodiversity and the costs associated with its loss. Economic valuation methods include market-based approaches, such as estimating the market prices of ecosystem services, as well as non-market approaches, such as stated preference surveys and cost-based methods.

Economic Incentives and Policies: This type focuses on designing and implementing economic instruments and policies to promote biodiversity conservation and sustainable use. It involves analyzing the effectiveness of various policy tools, such as taxes, subsidies, tradable permits, and payments for ecosystem services. The goal is to align economic incentives with biodiversity conservation objectives and encourage sustainable practices.

Economic Analysis and Decision-Making: This type of economics of biodiversity examines the economic trade-offs and impacts associated with different decisions and policies that affect biodiversity. It involves cost-benefit analysis, risk assessment, and impact assessment to inform decision-making processes. The aim is to integrate biodiversity considerations into economic planning, development projects, and resource management strategies.

Overall, the economics of biodiversity seeks to provide insights and tools for policymakers, businesses, and society at large to make informed decisions that consider both economic and biodiversity objectives, ultimately promoting sustainable development and the conservation of Earth's natural resources.

ECONOMICS OF BIODIVERSITY CONSERVATION:

The economics of biodiversity conservation refers to the application of economic principles and methods to understand, analyze, and address the challenges and opportunities associated with the conservation of biodiversity. It involves studying the economic value of biodiversity, assessing the costs and benefits of conservation actions, and developing strategies and policies to promote sustainable management of natural resources and protect ecosystems.

Biodiversity is crucial for maintaining the balance and functioning of ecosystems, providing a wide range of services that are essential for human well-being. These services include the provision of food, clean water, climate regulation, soil fertility, pollination, and natural pest control, among others. However, human activities, such as habitat destruction, pollution, overexploitation of resources, and climate change, are leading to the loss of biodiversity at an alarming rate.

The economics of biodiversity conservation recognizes that biodiversity has both intrinsic and instrumental value. Intrinsic value refers to the inherent worth of biodiversity and the moral and ethical arguments for its preservation. Instrumental value refers to the practical benefits and contributions of biodiversity to human societies and economies.

By applying economic analysis, researchers and policymakers can better understand the trade-offs, costs, and benefits associated with conservation actions. Economic tools such as cost-benefit analysis, ecosystem valuation, and market-based instruments are utilized to assess the economic impacts of biodiversity loss and the potential gains from conservation efforts. This economic perspective helps to inform decision-making processes and guide the allocation of resources towards biodiversity conservation in a more efficient and effective manner.

Furthermore, the economics of biodiversity conservation explores the role of economic incentives, policy instruments, and financial mechanisms to promote conservation. This includes exploring mechanisms such as payments for ecosystem services (PES), biodiversity offsets, and conservation trust funds. These approaches aim to align economic incentives with conservation goals, create economic value for the services provided by biodiversity, and support the sustainable management and protection of natural resources.

Overall, the economics of biodiversity conservation provides a framework for integrating economic considerations into conservation strategies and decision-making processes. It recognizes the importance of biodiversity for human well-being, emphasizes the economic value of ecosystem services, and seeks to find practical and sustainable solutions to the challenges of biodiversity loss and ecosystem degradation.

Here are three types of economics of biodiversity conservation:

Cost-Benefit Analysis: Cost-benefit analysis (CBA) is a common approach used in the economics of biodiversity conservation. It involves identifying and quantifying the costs and benefits associated with conservation actions. Costs may include expenses related to habitat protection, species monitoring, and enforcement of regulations, while benefits can include values associated with ecosystem services, tourism, and biodiversity-related research. CBA helps decision-makers compare the costs and benefits of different conservation actions and determine the most efficient use of resources.

Payments for Ecosystem Services (PES): PES is an economic approach that provides financial incentives to individuals or communities for maintaining or enhancing specific ecosystem services. It involves compensating landowners or communities for their efforts in conserving biodiversity and providing ecosystem services like clean water, carbon sequestration, or habitat preservation. PES schemes can be designed in various forms, including direct payments, market-based mechanisms, or voluntary agreements. This approach helps align economic incentives with conservation objectives, creating a win-win situation for both biodiversity and local communities.

Conservation Financing Mechanisms: The economics of biodiversity conservation also involves exploring different financing mechanisms to support conservation efforts. These mechanisms aim to mobilize financial resources for biodiversity conservation through innovative funding models. Examples include biodiversity offsets, where developers compensate for habitat loss by financing conservation projects elsewhere, and biodiversity conservation trust funds, which pool financial resources from various stakeholders to support conservation initiatives. By exploring new financial mechanisms, conservation efforts can be adequately funded and sustainable financing sources can be established.

It's important to note that these types of economics of biodiversity conservation are not mutually exclusive and can be used in combination. For instance, cost-benefit analysis can help inform the design of payments for ecosystem services programs, while conservation financing mechanisms can support and enable the implementation of effective conservation strategies.

By applying economic principles and tools to biodiversity conservation, decision-makers can better understand the economic implications of conservation actions, make informed choices, and implement strategies that effectively balance ecological, social, and economic considerations.

VALUING INDIVIDUAL SPECIES AND DIVERSITY OF SPECIES

Valuing individual species and diversity of species is an important aspect of the economics of biodiversity. It involves recognizing and assessing the worth and significance

of different species in ecological systems and human societies. Understanding the value of individual species and the diversity they contribute is crucial for informed decision-making regarding conservation efforts and resource management.

Here is an introduction to valuing individual species and diversity of species:

Value of Individual Species: Each species in an ecosystem has its own unique characteristics, functions, and contributions. Valuing individual species involves recognizing the specific ecological roles they play and the services they provide. For example, certain plant species may be essential for soil stabilization and erosion control, while specific animal species may be important pollinators or predators of pests. Additionally, some species may have cultural, aesthetic, or spiritual significance to human communities. The value of individual species can be assessed by considering their ecological functions, their economic contributions, and their cultural or intrinsic importance.

Value of Species Diversity: Species diversity refers to the variety of different species within a given ecosystem or area. Valuing species diversity recognizes the benefits that arise from having a rich and diverse range of species. Ecologically, species diversity contributes to the stability and resilience of ecosystems, as different species can fulfill various roles and functions. For example, high species diversity can enhance ecosystem productivity, nutrient cycling, and disease regulation. Species diversity also provides opportunities for scientific research, as each species may offer unique insights into evolutionary processes or potential applications in medicine and technology. Additionally, species diversity can have cultural and recreational value, as people appreciate the beauty and wonder of diverse ecosystems. The value of species diversity can be assessed by considering the various ecological, scientific, and cultural benefits it provides.

Methods for Valuation: Valuing individual species and diversity of species involves applying economic valuation methods. These methods can include market-based approaches, such as estimating the economic contributions of species through goods and services they provide (e.g., timber, medicinal plants, tourism), as well as non-market

approaches that capture the non-monetary values associated with species (e.g., existence value, cultural value). Techniques like contingent valuation surveys, stated preference methods, and hedonic pricing can be used to estimate the economic and non-economic values assigned to individual species and species diversity.

Recognizing and valuing individual species and diversity of species is essential for effective biodiversity conservation and management. It helps to raise awareness about the importance of each species and the cumulative benefits of maintaining diverse ecosystems. By integrating these values into decision-making processes, policymakers, businesses, and communities can prioritize conservation efforts, develop sustainable practices, and ensure the long-term well-being of both ecosystems and human societies.

POLICY RESPONSES AT NATIONAL AND INTERNATIONAL LEVELS:

Policy responses at both national and international levels are crucial in addressing the economics of biodiversity and promoting sustainable biodiversity conservation. Here are some key policy responses:

National Level:

Legal Frameworks and Regulations: Countries can develop comprehensive legal frameworks and regulations to protect biodiversity and ecosystems. These may include laws to regulate land use, wildlife trade, protected area management, and environmental impact assessments. By enforcing these regulations, countries can mitigate the negative impacts of human activities on biodiversity and ensure sustainable practices.

Economic Instruments: Governments can implement economic instruments that provide incentives for biodiversity conservation. These may include taxes, subsidies, and market-based mechanisms such as payments for ecosystem services (PES) and biodiversity offsets. These instruments help internalize the economic value of biodiversity and encourage sustainable land use and resource management practices.

Protected Areas and Conservation Planning: Establishing and effectively managing protected areas is a crucial policy response. Governments can designate national parks,

nature reserves, and other protected areas to conserve critical habitats and species. They can also develop conservation plans and strategies that identify priority areas for protection and outline measures to restore degraded ecosystems.

Integration into Development Planning: Governments can integrate biodiversity considerations into national development planning processes. This involves ensuring that biodiversity conservation is taken into account in sectors such as agriculture, forestry, infrastructure development, and energy. By incorporating biodiversity objectives into these sectors, countries can promote sustainable development practices that minimize negative impacts on biodiversity.

International Level:

Multilateral Environmental Agreements (MEAs): MEAs play a significant role in promoting international cooperation and setting standards for biodiversity conservation. The Convention on Biological Diversity (CBD) is the key international agreement focused on biodiversity conservation. It provides a framework for countries to set targets, develop national biodiversity strategies, and cooperate on issues such as access and benefit-sharing of genetic resources. Other MEAs, such as the Ramsar Convention on Wetlands and CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), also contribute to biodiversity conservation.

International Financial Support: International organizations and donor countries can provide financial support to countries for biodiversity conservation. This can include grants, loans, and technical assistance to enhance the capacity of developing countries in implementing conservation measures. Funding mechanisms such as the Global Environment Facility (GEF) and the Green Climate Fund (GCF) support biodiversity conservation projects worldwide.

Knowledge Sharing and Capacity Building: International collaboration in research, knowledge sharing, and capacity building is essential for addressing the economics of biodiversity. Countries can exchange experiences, best practices, and scientific knowledge through platforms such as the Intergovernmental Science-Policy Platform on Biodiversity

and Ecosystem Services (IPBES) and regional networks. Capacity-building initiatives can help enhance skills and knowledge in biodiversity management and conservation.

Corporate and Consumer Responsibility: International policies can also encourage corporate and consumer responsibility for biodiversity conservation. This can include promoting sustainable supply chains, certification schemes for responsible production practices, and raising consumer awareness about biodiversity-friendly products. International initiatives like the Roundtable on Sustainable Palm Oil (RSPO) and Forest Stewardship Council (FSC) promote responsible sourcing and production in industries that impact biodiversity.

These policy responses at national and international levels work together to create an enabling environment for biodiversity conservation. They aim to balance economic development with the sustainable use and protection of biodiversity, ensuring that future generations can continue to benefit from the services and values that biodiversity provides.

ECONOMICS OF CLIMATE CHANGE:

The economics of climate change is a field that focuses on understanding and addressing the economic implications of climate change, including its impacts on biodiversity. It examines the interactions between climate change, biodiversity, and economic systems, and seeks to identify policy responses and economic strategies to mitigate and adapt to climate change while conserving biodiversity.

When considering the economics of climate change in terms of biodiversity, it involves understanding how climate change affects ecosystems, species, and the services they provide, as well as the economic implications of these changes. Here is an introduction to the economics of climate change in relation to biodiversity:

Climate Change Impacts on Biodiversity: Climate change poses significant threats to biodiversity. Rising temperatures, changing precipitation patterns, and extreme weather events can lead to habitat loss, alteration of ecosystems, shifts in species distributions, and increased vulnerability to diseases and invasive species. These changes can disrupt

ecological interactions, reduce species populations, and even lead to extinction. The economic implications of climate change on biodiversity are wide-ranging, as they can affect sectors such as agriculture, fisheries, forestry, tourism, and human health, among others.

Economic Valuation of Biodiversity Impacts: The economics of climate change in relation to biodiversity includes valuing the impacts of climate change on biodiversity. Economic valuation methods can assess the economic costs associated with the loss of biodiversity and the degradation of ecosystem services resulting from climate change. This helps policymakers and stakeholders understand the economic trade-offs and make informed decisions regarding climate change mitigation and adaptation strategies.

Policy Responses: The economics of climate change in relation to biodiversity highlights the need for policy responses that integrate climate change and biodiversity conservation objectives. This includes implementing mitigation measures to reduce greenhouse gas emissions and limit the extent of climate change impacts on biodiversity. It also involves developing adaptation strategies to enhance the resilience of ecosystems and species to climate change effects. Policy responses may include promoting sustainable land and water management, establishing protected areas, and supporting the restoration of degraded ecosystems.

Synergies and Trade-offs: The economics of climate change and biodiversity also explores the synergies and trade-offs between climate change mitigation and biodiversity conservation efforts. For example, certain climate change mitigation measures, such as afforestation or renewable energy development, may have both positive and negative impacts on biodiversity. Understanding these synergies and trade-offs helps in designing policies and strategies that maximize the co-benefits and minimize potential conflicts between climate change mitigation and biodiversity conservation.

In summary, the economics of climate change in relation to biodiversity focuses on understanding the economic impacts of climate change on biodiversity and developing strategies to mitigate and adapt to these changes. By integrating economic analysis,

valuation methods, and policy responses, it aims to promote sustainable development while conserving biodiversity in the face of climate change challenges.

Stern Report:

The Stern Review on the Economics of Climate Change, commonly known as the Stern Review, is a landmark report commissioned by the UK government in 2005. While the Stern Review specifically focuses on climate change, it acknowledges the interconnections between climate change and biodiversity loss. Although the report does not specifically address the economics of biodiversity, it recognizes the economic implications of biodiversity loss and emphasizes the need to address both climate change and biodiversity conservation together.

The Stern Review highlights the economic costs of climate change and argues that early action to mitigate climate change is essential to avoid severe economic impacts in the future. It emphasizes the need for global cooperation, policy interventions, and investment in low-carbon technologies and infrastructure.

While biodiversity loss is not the primary focus of the Stern Review, it acknowledges the important role of ecosystems and biodiversity in climate change mitigation and adaptation. It recognizes that ecosystems provide numerous services that contribute to human well-being, such as carbon sequestration, water purification, and natural disaster protection. The report emphasizes that climate change mitigation strategies should consider the conservation and restoration of ecosystems to maximize their resilience and enhance their capacity to sequester carbon.

Furthermore, the Stern Review recognizes the potential economic value of biodiversity and the risks associated with biodiversity loss. It highlights that biodiversity loss can disrupt ecosystems, reduce the availability of natural resources, and negatively impact sectors such as agriculture, forestry, and tourism.

While the Stern Review does not delve extensively into the economics of biodiversity, it underscores the importance of considering biodiversity in the context of

climate change mitigation and adaptation. It emphasizes the need for integrated policies and strategies that address both climate change and biodiversity conservation to achieve sustainable development and safeguard economic prosperity.

It is worth noting that there have been subsequent reports and studies that specifically focus on the economics of biodiversity, providing more comprehensive analyses and policy recommendations in that specific field.

---------- **THE END** ----------