Introduction to Environmental Economics

(7 *Lectures*)

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Unit 1. Introduction

1. What is environmental economics;
2. Review of microeconomics and welfare economics.
3. Interlinkages between the economy and environment

Reference: ***Hanley N, Shogren J.F. & White B.,*** Environmental Economics in Theory and Practice**, Macmillan**

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Introduction to Environmental Economics

1 Introduction

Environmental economics is a subfield of economics concerned with environmental issues. Quoting from the National Bureau of Economic Research Environmental Economics program: Environmental Economics undertakes theoretical or empirical studies of the economic effects of national or local environmental policies around the world.

Particular issues include the costs and benefits of alternative environmental policies to deal with air pollution, water quality, toxic substances, solid waste, and global warming. Central to environmental economics is the concept of market failure.

Market failure means that markets fail to allocate resources efficiently. "A market failure occurs when the market does not allocate scarce resources to generate the greatest social welfare. A wedge exists between what a private person does given market prices and what society might want him or her to do to protect the environment.Such a wedge implies wastefulness or economic inefficiency; resources can be reallocated to make at least one person better off without making anyone else worse off."

Common forms of market failure include externalities, non excludability and non rivalry.

Environmental economics is related to ecological economics but there are differences. Most environmental economists have been trained as economists. They apply the tools of economics to address environmental problems, many of which are related to so-called market failures- circumstances wherein the "invisible hand" of economics is unreliable.

Most ecological economists have been trained as ecologists, but have expanded the scope of their work to consider the impacts of humans and their economic activity on ecological systems and services, and vice-versa. This field takes as its premise that economics is a strict subfield of ecology. Ecological economics is sometimes described as taking a more pluralistic approach to environmental problems and focuses more explicitly on long-term environmental sustainability and issues of scale.

Environmental economics is viewed as more pragmatic in a price system; ecological economics as more idealistic in its attempts not use money as a primary arbiter of decisions. These two groups of specialists sometimes have conflicting views which may be traced to the different philosophical underpinnings. Environmental economics was once distinct from resource economics. Natural resource economics as a subfield began when the main concern of researchers was the optimal commercial exploitation of natural resource stocks.

But resource managers and policy-makers eventually began to pay attention to the broader importance of natural resources It is now difficult to distinguish "environmental" and "natural resource" economics as separate fields as the two became associated with sustainability. Many of the more radical green economists split off to work on an alternate political economy.

Environmental economics was a major influence for the theories of natural capitalism and environmental finance, which could be said to be two sub-branches of environmental economics concerned with resource conservation in production, and the value of biodiversity to humans, respectively. The theory of natural capitalism (Hawken, Lovins, Lovins) goes further than traditional environmental economics by envisioning a world where natural services are considered on par with physical capital.

The more radical Green economists reject neoclassical economics in favour of a new political economy beyond capitalism or communism that gives a greater emphasis to the interaction of the human economy and the natural environment, acknowledging that "economy is three-fifths of ecology" – Mike Nickerson.

2 Origin & Meaning of Environmental Economics

Origin of environmental economics is related with the concept of market failure. Repairing of market failure needs government intervention. A policy interference by the government need the suggestions from environmental economists.

In the words of D.W. Pearce, "Environmental Economics brings the discipline of economic analysis to environmental issues such as pollution, the rate of use of renewable and non-renewable natural resources, conservation of living species and resources, and the choice of policy to achieve environmental ends." The mainstream economics is based on market mechanism. Its primary emphasis is on the market as a supplier of advice about human preferences. It focuses on the rational behaviour of consumers and producers. It studies the micro and macro aspects of the economy. But economics differs from environmental economics.

In economic sense, pollution is termed as any loss of human well being arising from physical environmental change. Pollution may also have short- run or long-run impacts upon the health of human beings. Resource issues, as pointed out by D.W. Pearce, may be interpreted as possible degradation of the human environment. Other forms of degradation may also be added, such as the exploitation of natural resources other than for crop land (for housing/transport etc.), the exhaustion of non-renewable resources (such as oil and mineral), and the mismanagement of renewable resources.

According to Charles Kolstad, the best division between environmental economics and resource economics is between static and dynamic issues related to the natural world. "Environmental economics involves questions of excessive production of pollution by the market (or insufficient protection of the natural world due to market failure). Resource economics, on the other hand, is concerned with the production and use of natural resources, both renewable and exhaustible. Renewable resources would include fisheries and forests. Non-renewables would include minerals and energy as well as natural assets."

3 Subject matter of Environmental Economics

There are different approaches on the subject matter of environmental economics.

(A) Natural Resources Scarcity Approach
(B) Economic Growth and Environment
(C) Population Growth and Environmental Crisis
(D) Impact of Climate Change

3.1 Natural Resources Scarcity Approach

Classical economists have expressed their arguments on natural-resources scarcity. Malthus has analysed this problem in relation to the growth of population. "Population has this constant tendency to increase beyond the means of subsistence, and that it is kept to its

necessary level by these causes and thus, humankind, is necessarily confined in room by nature."

It means that if the pressure of increasing population continues in relation to food supply, then human life is destined to be miserable. Hence the pace of economic development will be retarded due to growth in population with limited natural resources.

J.S. Mill has extended the natural-resources scarcity approach to nonrenewable mineral resources. "The only products of industry, which, if population did not increase, would be liable to a real increase of cost of production, are those which depending on a mineral which is not renewed, is either wholly or partially exhaustible such as coal, and most if not all metals for even iron, the most abundant as well as most useful of metallic products, which forms an ingredient of most minerals and of almost all rocks, is susceptible of exhaustion."

In the words of Dr Herbert Ginits, "Balancing the goal of improving the natural environment against other desirata such as increased consumption and leisure is a problem of Marshallian scarce resources towards competing ends, to use the well-known phrase of Lionel Robbins. However, these views do not concern about environmental problems."

The classical school considers environment as a free good. But, society has overused the natural resources, leading to environment degradation. Marshall does not assume any absolute resource limits but only admits that resources decline with limited productive powers of nature. Ricardo argued that relative scarcity is a problem of growing economy. Relative scarcity is set by rising costs as the highest grade resources which are exploited and substituted for all low grade resources.

3.1.1 Marxist Ecological Approach

Marx is against capitalism. Under capitalism, every capitalist is engaged in introducing labour saving methods and replacing the labour by machines. The natural environment is polluted by installing more machines by capitalists.

In the words of Marx, "The forces of nature are appropriated as agents of labour process only by means of machines and only by the owners of machines. The application of these forces of nature on a broad scale is only possible where machines are used on a broad scale." In short, we may say that mechanical methods lead to man‘s exploitation of nature in his own interests.

F. Engels has expressed his views on Economic growth and Environmental crisis. He is of the view that man is a product of nature and also a part of it. Therefore, economic growth need not damage man‘s harmony with nature. In an essay entitled, "The Part Played by Labour in the Transition from Ape to Man", he has expressed his views thus: "Let us not, however, flatter ourselves over much on account of our human victories over nature. For each such victory nature takes its revenge on us we are reminded that we by no means rule over nature, like someone standing outside nature, but that we. . . . . ..belong to nature."

3.1.2 Chicago Approach

According to this approach, in the real world, there is always market failure due to externalities. Externalities are market imperfections where the market offers no price for service or disservice. For example, a factory situated in a residential area emits smoke which affects adversely health and household articles of the residents.

In this example, the factory benefits at the expense of residents who have to incur extra expense to keep themselves healthy and the households clean. These are social marginal costs because of harmful externalities which are higher than private marginal cost and also social marginal benefits. To protect the society's gain, Pigou suggests state interference by imposing pollution tax or subsidies to firms to reduce the pollution.

Pigou's approach to externalities has been challenged by Dr. Coase. According to him, the main source of externalities is an inappropriate assignment of property rights. If property rights are clearly defined then the affected parties will adopt policies to internalise the externalities.

Dr. Coase explains his arguments with the help of an example. He assumes only two parties, a cattle raiser and a wheat producing farmer. They are operating on neighbourhood properties without any fencing. The externality is the damage done by the cattle roaming on the unfenced land of the farmer.

As the cattle raiser increases the size of the herd, the damage to the farmer's crop increases. According to Dr. Coase, property rights should be properly defined and enforced. The farmer has the right that his wheat be not destroyed. Therefore, the cattle raiser will then be forced to pay damages to the farmer for the crop destroyed.

3.1.3 Conservation Approach

Ciriacy-Wantrup has advocated a safe minimum standard approach for natural resources use. In the face of uncertain demand and uncertain technological improvements that create substitutes, a certain minimum of preservation would give some options for future use.

This approach suggests to adopt a conservation process which involves the identification of a safe minimum standard of critical zone of renewable resources use because of the uncertainty and irreversible degradation of these resources. It is the prime duty of the institutions to safeguard against the inefficiency in the use of these resources.

K.W. Kapp argued that destruction of renewable resources is the result of uncontrolled competition in the utilization of these resources. Over hunting, over fishing, excessive timber felling and exhaustion of the soil have led and still lead to the extinction of species and erosion of fertile land.

He also deals with the problems of non-renewable resources like oil and coal. As a result of cut-throat competition, great waste occurs in production and here too no allowance is made for the consequences for future generations. For maintaining a stable ecosystem, he stresses on abiotic conditions such as the quantity of nutrient salts, soil structure, ground-water level, degree of acidity and humidity.

K.E. Boulding argued that earth's environmental resources should be viewed as essential irreplaceable social capital and the main purpose of economic activity should be to conserve this stock of natural capital intact for future generations. To put it more precisely, environment is the resources potential on which mankind depends and development consists of transforming elements of environment into resources.

Diachronic solidarity with future generations compel us to reject predatory from hand to mouth practices of cowboy economy and to seek instead a pattern of resources use based as much as possible on sustainability.

3.1.4 Technological Approach

The technological approach to the environment emphasizes the link between the nature of technological change that has taken place and its environment implications. Barry Commoner believes that the main purpose of business firms is to maximize their profits in an economic system. Moreover, profits of business firms have increased with the advancement of technology. But what happened to environment? He explains two facts regarding environment.

First, pollution tends to become intensified by the displacement of older productive techniques by new, ecologically faulty but more profitable technology. Thus, in these cases, pollution is an unintended concomitant of the natural drive of the economic system to introduce new technologies that increase productivity.

Second, the cost of environmental degradation is chiefly borne not by the producer but by society as a whole in the form of externalities. In support of his views, he says that there are vital changes in the nature and composition of commodities produced in U.S.A. after World War II.

Since 1946 the provision of basic goods such as food, clothing and shelter grew in proportion to the growth of population but the environmental impact of these goods has also increased. B. Commoner uses the term "technology" to indicate the qualitative changes in production with damaging environmental consequences.

B. Commoner is of the view that in most of these changes that have been part of our economic growth since 1946, the new technology has an appreciably greater damaging impact on the environment than the technology it displaced. On the basis of his studies, he concludes that the postwar technological transformation of productive activities is the chief reason for the present environmental crisis.

He argues that productive activities with a large damaging effect on the environment have displaced those with much less serious damaging effect. But it does not imply that technology is by its very nature detriment to the environment. It does not mean that the advantages that accompany technology must be scarified. We must try to develop new technologies that incorporate ecological wisdom.

E.F. Schumacher considers appropriate technology which is labour intensive, energy saving, producing little pollution and also employment generating. Huber considers ecological modernization in place of technological changes. Ecological modernization refers to a process of an ecological switch over to industrialization process. It is a way out of the environmental crisis. Accordingly, crisis can be averted by adopting cleaner technologies.

3.1.5 Ethical Approach

Lester Brown regards pollution as an ecological stress on mankind. According to him, "Pollution is more than a mere nuisance. It can impair and even destroy the productivity of local biological systems. It can ruin forests, crops and fisheries, fresh water lakes and streams, destroy whole species of plants and animals, impair human health, break up the ozone layer, impede the exchange of oxygen and carbon dioxide between the oceans and the atmosphere; and even damage clothing; buildings and status."

Further, new challenges before mankind are population growth and climate changes. Climate changes are due to fossil fuel or carbon-based economy. Therefore, there is a need for stabilizing climate. Stabilizing climate means shifting away from carbon-based economy to solar-hydrogen economy.

Second, there must be a change in human reproductive behaviour.

Third, there must be some social changes in the global economy in terms of values and lifestyle of the people so that it does not degrade its natural system.

Fourth, another ecological stress is in the form of physical deteriorating grasslands and soil erosion.

Fifth, at the next level, the stresses manifest themselves in economic terms— scarcity, inflation, unemployment, and economic stagnation or decline.

Sixth, the stresses assume a social and political character—hunger, forced migration to the cities, deteriorating living standards, and political unrest.

The need to adapt human life simultaneously to the carrying capacity of the earth's biological systems and to the limits of renewable energy sources will require a new social ethic. The essence of this new ethic is accommodation—the accommodation of human numbers and aspirations to the earth's resources and capacities.

Above all, this new ethic must arrest the deterioration of man's relationship to nature. If civilization as we know it is to survive, this ethic of accommodation must replace the prevailing growth ethic of unlimited exponential growth and great faith in technological fixes.

3.1.6 Socio-Economic Approach

Dr. Mostafa K. Tolba lays emphasis on socio-economic approach. According to him, we may now look upon environment as the stock of physical or social resources available at a given time for the satisfaction of human needs, and upon development as a process pursued by all societies with the aim of increasing human well-being. Thus the ultimate purpose of both environmental and developmental policies is the enhancement of the quality of life, beginning with the satisfaction of the basic human needs.

Further, environmental problems are caused by lack of adequate development. Today there are hundreds of millions of people without the basic human necessities like adequate food, shelter, clothing and health, and hundreds of millions more lack access to even a rudimentary education.

This is not only an intolerable situation in human terms, but it also has serious environmental consequences. The relentless pressures that arise where basic human needs are not met erase the resource base from which man must inevitably gain his sustenance.

The destruction of forests, the loss of arable soil, the loss of productivity through disease and malnutrition and the increasing pressure on fragile ecosystems which so often result from poverty. These things are as significant as the pollution created by industry, technology and over-consumption by the affluent. All of them lead to the rapid depletion of natural resources. Many human settlement problems also arise from lack of adequate development.

In support of his argument, Dr. Tolba suggests that in the industrialized countries, it will be necessary to reorient society's aims so that the entire population has more opportunity for self-expression in the fields of culture, education and humanities. These non-physical areas of development represent the highest levels of human achievement.

This new orientation must be less demanding on the environment, in particular on natural resources and energy. Present patterns of production and consumption, based on waste, extravagance and planned obsolescence, must be replaced by conservation and reuse of resources.

Developing countries, which still lack the infrastructure and readily useable resources are required to meet the growing needs and aspirations of its people. This approach must

continue to have a strong physical orientation.

But in earlier stages, each country should be helped to follow a path to development best suited to its own human skills and natural resources. This responds to its own needs and accords with its own culture and value systems. It should adopt environmentally sound technologies in relation to its natural resources of soil, water, plant and animal life, and should avoid the destruction of the resource base.

3.2 Economic Growth and Environment

Since the times of Malthus, Ricardo and Mill, economists like Galbraith, Mishan, Boulding, Nordhaus, Commoner, etc. have voiced their concern about the harmful effects of economic growth on environment. They are of the view that economic growth has produced pollution and wasteful consumption of trivia that contribute nothing to human happiness.

According to them, the objectives of economic growth are to be reviewed because it has negatively affected the quality of life, pollution of the environment wastes of natural resources and its failure to solve socio-economic problems.

E.J. Mishan has expressed his anti-growth arguments in his book entitled The Costs of Economic Growth. According to him, "It is hardly possible to move along this golden path of self-perpetuating economic growth without subjecting people to manifold pressures. Moreover, pressures appear to increase both the stage of economic, growth and with the rate of economic growth."

Lester Brown has pointed out at the present state of economic growth. He argues that economic benefits are out-weighted by the costs. These costs are more rapid depletion of natural resources, urban problems like congestion, noise pollution and problems of the country side such as strip mining and the indiscriminate clear cutting of timber.

3.3 Population Growth and Environmental Crisis

Of the classical economists, especially Malthus has expressed his views on population growth and environmental crisis. There is a social and environmental crisis in Malthusian population trap model. In the words of Malthus, "Population has this constant tendency to increase beyond the means of subsistence, and that it is kept to its necessary level by these causes and thus, humankind, is necessarily confined in room by nature."

Thus Malthus foresaw humanity deprived, depraved and malnourished because its appetites would inevitably overtax the capacity of the available farmland to produce food. The neo-classical economists have analysed the relation between population growth and environmental crisis in terms of the vicious circle. Rapid population growth (or high fertility rate) leads to poverty and low status of family members especially women and children in society.

Further, scarcity of land and housing facilities pushes large number of people to ecological sensitive areas. Moreover, exploitation of natural resources by overgrowing and cutting of forests for cultivation lead to severe environmental damages.

3.4 Impact of Climate Change

Climate changes have always affected humans. The most difficult and challenging problems before mankind are global warming, acid rains, ozone depletion, changes in rainfall

pattern etc. These may have far reacting effects on the global ecosystem.

Economists have analysed the impact of climate changes on agriculture, wild life, human life and water resources etc.

4 Concept of Environmental Economics

4.1 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.

4.2 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.

4.3 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:

1. **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.

2. **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.

4.4 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 is 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.

4.5 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.

4.6 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 anthropogenetic factors. They also face short and long run natural changes imposed from both within and outside the systems such as climatic changes Let us explain the functions of ecosystems with examples.

The major components within the ecosystem are lithosphere (solid earth), the atmosphere, the hydrosphere (water) and the biosphere. There is also the cryosphere (of ice and snow).

4.6.1 Ecosystem Diversity

The ecosystem diversity can be classified into two major types: **(a) The aquatic,** and **(b) The terrestrial.**

The aquatic eco-systems are further classified into marine, estuarine and freshwater while the terrestrial are divided into sixteen biomes representing major formations in terms of vegetation types.

4.6.2 Social Carrying Capacity

Biophysical carrying capacity expresses "the maximum population size that could be sustained under given technological capabilities". Social carrying capacity can be defined as the "maximum numbers of human beings which the environment can support". The population generally stabilizes around the carrying capacity.

Hardin, Ehrlich and Daly have applied the concept to environmental impacts of human activities. Social carrying capacity is determined by the influence of human consumption patterns, technological changes and its impact on the environment. It stresses on the fact that nature s bounds can be transgressed by rapidly growing population and accelerated use of natural resources.

We may conclude that sustainable carrying capacity as the maximum number of persons that can be supported in perpetuity on an area with a given technology and set of competitive habits without causing environmental degradation.

4.6.3 Eco-development

It has been defined as ecological sound development which is a process of positive management of the environment for human benefit. Eco-development and sustainable development are interchangeable.

4.6.4 Economic Sustainability

The most common interpretation of economic sustainability is maintaining a nondeclining level of economic welfare now and into the future. This economic welfare is derived from the income generated by the capital stocks which include manufactured capital, human capital and natural capital.

4.6.5 Environmental Goods

Environmental goods are public goods. They include air quality, water quality and sun heat etc. Environmental goods are unique in nature. Excess use of these may lead to environmental degradation. For example, due to global climate change, the snow on the peaks of the Himalayas starts losing its density and thickness.

5 Ecology & Thermodynamics

- **Explain how the first and second laws of thermodynamics apply to ecosystems.**

1. The first law of thermodynamics states that energy cannot be created or destroyed, only transformed; Energy enters an ecosystem as solar radiation, is conserved, and is lost from organisms as heat.

2. The second law of thermodynamics states that every exchange of energy increases the entropy (i.e., the ratio of non-usuable mattter to usuable matter) of the universe; In an ecosystem, energy conversions are not completely efficient, and some energy is always lost as heat.

- **Explain how the law of conservation of matter applies to ecosystems.**

  The law of conservation of mass states that matter cannot be created or destroyed; Chemical elements are continually recycled within ecosystems. Matter can go through physical, chemical or nuclear changes. In a forest ecosystem, most nutrients enter as dust or solutes in rain and are carried away in water. Ecosystems are open systems, absorbing energy and mass and releasing heat and waste products.

- **Explain why energy flows but nutrients cycle within an ecosystem.**

  Energy and nutrients pass from primary producers (autotrophs) to primary consumers (herbivores) to secondary consumers (carnivores) to tertiary consumers (carnivores that feed on other carnivores), but energy can be released as heat into the environment, while nutrients remain within the environment through fecal matter.

- **Who are autotrophs?**

  Autotrophs build molecules themselves using photosynthesis or chemosynthesis as an energy source.

- **Who are heterotrophs?**

  Heterotrophs depend on the biosynthetic output of other organisms.

- **What does producers do?**

  Carbon dioxide + water = glucose + oxygen (reverse of pro)

- **What does consumers do?**

  Glucose + oxygen = carbon dioxide + water (reverse of con)

- **Who are detritivores/decomposers?**

  Detritivores/ Decomposers are consumers that derive their energy from detritus, nonliving organic matter (Prokaryotes and fungi are important detritivores).

- **Who are primary producers?** Autotrophs.

- **Who are primary consumers?** Herbivores.

6 Nature of Environmental Economics

Environmental economics is considered both as positive and normative science. It also covers both micro and macro aspects of different pollution problems.

6.1 Positive and Normative aspects

Environmental economics is an application of scientific theories and general application of welfare economics. When we study the cause and effect relationship, it covers the positive aspect. For example, the laws of thermodynamics are equally applicable to economic process.

If the problem is related to policy measures, then it is considered as normative aspect. Therefore, environmental economics is a normative science because it prescribes the goals of environmental policy. As pointed out by B. C. Field, "Environmental degradation is the result of human behaviour that is unethical or immoral. Thus, for example, the reason people pollute is because they lack the moral and ethical strength to refrain from the type of behaviour that cause environmental degradation. If this is true, then the way to get people to stop polluting is somehow to increase the general level of environmental morality in the society." Field calls it as moral approach to environmental issues.

6.2 Micro and Macro aspects

Economists such as Pigou, Hoteling and Nordhaus have formulated their models in relation to individual firms and natural resources. Therefore, it covers the micro and macro aspects of the pollution problem. There are many examples of micro and macroaspects of environmental problems in the present times.

We generally observe crowded market places, industrial units, and even residential areas in a city like, Delhi. We do not get enough fresh air at these places. Its solution lies in micro level planning. On the other-hand, when the pollution problem is related to the economy as a whole such as rise in temperature, then it is related to macro aspect of environmental planning.

Environmental economics draws more from microeconomics than from macroeconomics. It focuses primarily on how and why people make decisions that have consequences for the natural environment. It is concerned also with how economic institutions and policies can be changed to bring these environmental impacts more into balance with human desires and the needs of the ecosystem.

6.3 Static and Dynamic aspects

Classical and Neoclassical economists have applied both static and dynamic approaches in relation to environment. They have applied economic welfare approach to environment which is static in nature, whereas under dynamic approach, they focus on forests, minerals, fossil fuels and water resources etc.

6.4 Environmental Economics: A Social Science

Environmental economics deals with economic and managerial aspects of pollution and natural resources. It interacts between human beings and their physical surroundings. It

studies the impact of pollution on human beings and suggests national utilization of resources in a proper way so that there may be an increase in social welfare or minimization of social costs.

Environmental economics is also concerned, with the natural environment, but not exclusively so. For example, man-made and cultural or social environments may also be a part of the nature of environmental economics.

6.5 Environmental Pollution: 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.

More exploitation of it means more pollution. Environmental pollution as an economic problem is explained in terms of **Figure 1**.

In this connection Ian Hodge points out, "What we will find is that choices made about the environment depend upon similar factors as do choices made in other areas of economics. Our views of changes in environmental quality depend (as do all prices) upon supply and demand factors: how much of the environment is supplied for particular purposes and how much is demanded." Thus, the forces of supply (production) and demand (preference for clean environment) and market instruments used by the state are important issues in environmental policy.

Economic growth can affect environmental quality under different situations.

Environmental quality can increase with economic growth. Thus increased incomes, for example, provide the resources for public services.

First, with availability of these services individuals can devote more resources for conservation.

Second, environmental quality can initially worsen but then improve as thegrowth rate rises.

Third, environmental quality can decrease when the rate of growth increases.

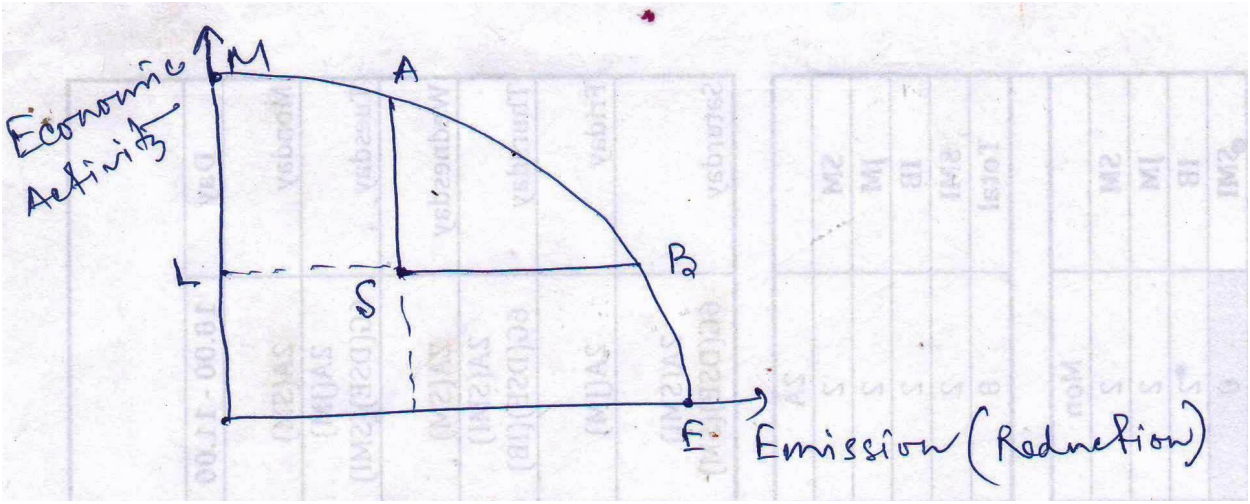

Figure 1: Economic Activity and Emission

7 Scope of Environmental Economics

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

7.1 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.

All economic activities either affect or are affected by natural and environmental resources. Activities such as extraction, processing, manufacture, transport, consumption and disposal change the stock of natural resources, add stress to the environmental systems and introduce wastes to environmental media. Moreover, economic activities today affect the stock of natural resources available for the future and have inter-temporal welfare effects. From this perspective, the productivity of an economic system depends in part on the supply and quality of natural and environmental resources.

Natural and environmental resources have **three** economic roles :

- waste disposal services, related to the environment‘s assimilative capacity;
- natural resource inputs into production; and
- directly consumed life support services and aesthetic amenities.

The natural and environmental resource input function is central to understanding the relationship between economic growth and environment. Water, soil, air, biological, forest and fisheries resources are productive assets, whose quality helps determine the productivity of the economy. Focusing on this role of environment as a producer good highlights the direct effect environmental problems have on economic growth. Thus, economic management impacts on the environment and the environmental quality impacts

on the efficient working of the economy. Environmental degradation imposes costs on the economy which results in output and human capital losses.

Lost labour productivity resulting from ill health, foregone crop output due to soil degradation and erosion, lost fisheries output and tourism receipts from coastal erosion or lost soil productivity from deforestation can be some of the manifestations of such reduced output. Moreover, a growing body of epidemiological studies suggest that air and water pollution are taking a heavy toll, particularly of people in the developing world, through ill health and premature mortality. The impact of water and air pollution is particularly adverse to the younger, the very aged and poor. Pollution control, is thus linked to sustainable development and not a "luxury good" to be afforded after the development process has taken off.

7.2 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.

7.3 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.

7.4 Dynamic and Stock-flow Analysis

The mainstream economics is largely confined to the static problems of market behaviour. 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.

7.5 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.

7.6 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.

7.7 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.

7.8 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.

7.9 Multi-disciplinary Base

Environmental economics is inherently a multi-disciplinary subject. It consists of an integration of many varied disciplines such as biology, ecology, physical sciences, ethics and main stream economics. Therefore, it has wide scope.

8 Ecological Limits

What's wrong with continuing business as usual? There's increasing evidence that the human species is close to filling the ecological space available to it and other land-based species. It's hard to dispute that there is a limit; the question is, how close are we to reaching that limit and how much can we gain by arguing the fine points rather than getting on with making a shift to sustainability?

8.1 Human Biomass Appropriation:

The best evidence that there are imminent limits is the calculation by Peter Vitousek et al.1 that the human economy today uses – directly or indirectly – about 40% of the net primary product of terrestrial photosynthesis. (This figure drops to 25% if the oceans and other aquatic ecosystems are included.) After only a single doubling of the world's population (say, in 35 years) we will use 80%, and 100% shortly thereafter.

8.2 Global Warming:

Scientists now practically universally agree that global warming will occur, although differences remain on the rates. Greenhouse warming is a compelling argument that ecological limits have been exceeded because it is globally pervasive, rather than disrupting the atmosphere only in the regions where the CO2 was produced. The nearly 7 billion tons of carbon released into the atmosphere each year by human activity (from fossil fuel consumption and deforestation) accumulate in the atmosphere, which suggests

that the ecosystem's sinks capable of absorbing carbon have been exceeded, and carbon accumulation appears for all practical purposes irreversible on any relevant time frame.

8.3 Ozone Shield Rupture:

Although 85% of CFCs are released in the industrial North, the main ozone hole has appeared over Antarctica, showing the damage to be widespread and truly global. The global ozone layer is thinning far faster than models had predicted. A second hole has been discovered over the Arctic, and ozone-shield thinning recently was detected over both north and south temperate latitudes, including northern Europe and North America.

Even if CFC emissions cease today, the world still will be gripped in an unavoidable commitment to 10 years of increased damage. This would then gradually return to pre-damage levels over the next 100 to 150 years.

8.4 Land Degradation:

Land degradation – decreased productivity such as caused by accelerated soil erosion, salination, and desertification – is not new; land degraded thousands of years ago (for example, in the Tigris-Euphrates Valley) remains unproductive today. But the scale has mushroomed.

Pimentel et al.2 found that soil erosion is serious in most of the world's agricultural areas and that this problem is worsening as more marginal land is brought into production. Soil loss rates, generally ranging from 10 to 100 tons per hectare per year, exceed soil formation rates by at least tenfold. Today's agricultural practices are leading to erosion, salination, or waterlogging of possibly 6 million hectares per year.

As a result of widespread deficiencies in fuel wood, crop residues and dung are being diverted from agriculture to fuel. This diversion coupled with fuel wood overharvesting intensify land degradation, hunger, and poverty. As 35 percent of the Earth's land already is degraded, and because this figure is increasing and is largely irreversible in any time scale of concern to society, such degradation is a sign that we have exceeded the regenerative capacity of the Earth's soil source.

8.5 Decrease in Biodiversity:

The scale of the human economy has grown so large that there is no longer room for all species in the ark. The rates of takeover of wildlife habitat and of species extinctions are the fastest they have been in recorded history and are accelerating. The world's richest species habitat, tropical forest, has already been 55 percent destroyed; the current rate exceeds 168,000 square kilometers per year.

Conservative estimates put the rate of extinction at more than 5,000 species each year. This is about 10,000 times as fast as prehuman extinction rates. Less conservative estimates put the rate at 150,000 species per year.

9 Welfare Economics

Welfare economics studies the conditions under which the solution to a general equilibrium model can be said to be optimal. This requires among other things, an optimal allocation of factors among commodities and an optimal allocation of commodities (i.e distribution of income) among consumers. In welfare economics attempt is made to establish criteria or norms, with which to judge or evaluate alternative economic states and policies from the view point of the society's well-being.

In the words of Oscar Lange, "welfare economics establishes norms of behavior which satisfy the requirements of social rationality of economic activity." The term "Social rationality" of economic activity is to be interpreted as that activity which ensures optimum allocation of resources and therefore guarantees maximum social welfare. In this context Oscar Lange says, "The norms of behavior established by welfare economics are supposed to guarantee the optimal allocation of economic resources of the society."

The inter-relationship among various parts of the economy implies that certain specific change in one past of the economy affects resource allocation in all other parts of the economy. Thus, a central problem in welfare economics relates to whether a specific change in resource allocation will increase or decrease its social welfare.

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9.1 Pareto Optimality

Developed by the Italian economist, Vilfredo Pareto, the Pareto optimality criterion is the cornerstone of modern welfare economics. The criterion is used to determine whether the social welfare is higher in one economic situation than in another.

According to the Pareto optimality criterion, a distribution of inputs among commodities and of commodities among consumers is Pareto optimal or pareto efficient if, no reorganization of production or consumption is possible by which some individuals are made better off (in their own judgment) without making someone else worse off.

In other words, Pareto optimal is a situation in which it is impossible to make anyone better off without making someone else worse off. This situation is also called Pareto efficient. It follow that any change that improves the well- being of some individuals without reducing the well-being of others, clearly improves the welfare of society as a whole and should be undertaken. This will move the society from a Pareto non-optimal position to Pareto optimum. Once at Pareto optimum, no reorganization of production and exchange is possible that makes someone better off without, at the same time, making someone else worse off.

In a Pareto optimal state of an economy, it is impossible to make any one better off without making someone worse off by any of the following three means;

1. **Efficiency in Exchange**: Re-allocation of the already available goods among consumers.

2. **Efficiency in production:** (Optimal allocation of factors) Re-allocation of inputs among producers (in order to increase the output of some goods without reducing the output of any other good.)

3. **Efficiency in product Mix:** (Optimal Composition of output) Changing the composition of output that is, producing more of some and less of others.

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3. Changing the composition of output that is, producing more of some and less of others.

Reference: Hall Varian: Intermediate Microeconomics

9.2 General Equilibrium of Exchange

In this module, we examine general equilibrium of exchange for a very simple economy composed of only two individuals (A and B) and two commodities (X and Y): In this exchange system, we assume that there is no production. That is, we consider the case when two commodities are provided to the individuals in the economy from out side the system. Such possessions are called the initial endowments of individuals A and B. Now, suppose the individuals engage in an exchange 80 as to maximize their satisfaction. This

process of exchange can be better understood through the Box diagram (named after the neo-classical English economist of the early twentieth century, F.Y. Edgeworth who popularized the use of box diagrams in economics). The dimensions of the box measures total quantity of x, measured along the x-axis, and total quantity of y, measured along the y-axis. Each point in the **Edgeworth Box Diagram** represents all feasible allocations in this simple economy.

General equilibrium of Exchange is based on the following assumptions.

Assumptions:

(1) Two individuals A and B endowed with fixed amounts of only two commodities x and y

(2) Both individuals know each others preferences

(3) Each individual will take prices as given and optimize accordingly.

With the above assumptions, the general exchange equilibrium would lie same where on the Contract curve , that is, the line which passes through the tangency points line of the indifference curves of the two individuals. At these tangency points of indifference curves, MRS^A_{xy} of individual A is equal to the MRS^B_{xy} of individual B. Any point where the indifference curves are tangent, constitutes a consumption point where no further gains from trade or exchange are possible. Thus, the general equilibrium of exchange will occur general equilibrium of exchange will occur when the following condition holds good:

$$MRS^A_{xy} = MRS^B_{xy}.$$

This equilibrium condition tells us that an efficient exchange is obtained where the indifference curves of individuals A and B are tangential to each other; We can hence obtain a locus of these efficiency points known as the **Contract Curve**. Any movement along the contract curve is a gain of utility to one individual and loss to the other. Contract curve it-self does not depend on the initial endowment.

Contract curve describes all the possible efficient outcomes of mutually advantageous trade or exchange from starting anywhere in the Edgeworth Box. Given the initial endowment Point, We can get the subset of the contract curve that each individual prefers to his initial endowment.

From the above discussion it follows that given the initial endowment point, the general equilibrium of exchange can occur somewhere between M and N on the contract curve. On all points between M and N, the exchange equilibrium can exist. Although equilibrium will exist at a point on the contract curve, there is no unique position of exchange equilibrium; all points on the contract curve are possible equilibrium positions.

Utility possibility curve (UPC) is derived from consumption contract curve. By plotting the consumption contract curve form the output space into a utility space, we get the corresponding utility possibility curve . UPC shows the various combinations of utilities derived by individuals A and B (i.e, U_A and U_B) when this simple economy is in general equilibrium in exchange. We measure A's utility on x-axis and B's utility on y-axis.

Utility possibility curve which shows the various levels of utilities derived by two individuals A and B of the society resulting from the redistribution of a fixed bundle of goods and its consumption by them. Note that the points in the Edgeworth Box diagram, located away from the consumption contract curve are inside this utility possibility curve. A point inside the utility possibility curve and hence shows an inefficient allocation of x and y commodities between individuals A and B.

9.3 General Equilibrium of Production

We now proceed to examine the general equilibrium of production in a simple economy (in which no exchange takes place). We list the chief assumptions of the model below.

Assumptions:

1. There are 2 factors of production, labour (L) and capital (K), which are perfectly homogenous and perfectly divisible. The total endowment of each factor of production in the economy is fixed and given.

2. There are 2 commodities, X & Y produced in the economy; each commodity is homogeneous and perfectly divisible. The production functions of x and y exhibit constant returns to scale and are independent of each other. Further, the isoquant maps of both x and y are well-behaved, i.e, smooth and convex-to-origin, implying a diminishing marginal rate of technical substitution's (MRTS).

3. There is perfect competition in commodity and factor markets.

4. Technology is given.

5. Labour and capital can be transferred freely from the production of x to y and vice versa.

To examine general equilibrium of production, we deal with a very simple economy that produces two commodities (x & y) with only two inputs, labour (L) and capital (K). We construct an **Edgeworth Box diagram** for production from the isoquants for commodities x & y. Assuming the amounts of labour and capital as given and fixed, the Edgeworth Box diagram can be constructed. The measurements of the box are quantities of labour and capital which are to be allocated between two products / industries. The **contract curve** for production is obtained by joining these tangency points of the isoquants of x & y. That is, the condition

$$MRTS^{X}_{LK} = MRTS^{Y}_{LK}$$

is satisfied along the Contract curve.

It can be depicted that the general equilibrium of production would occur somewhere on this contract curve for production. The distribution of factors stated by the point away from thecontract curve such as point A cannot be the possible position of general equilibrium of production. This is due to the fact that from the point A where isoquant X_2 and isoquant Y_2 are intersecting, the 2 firms can move by re-distributing resources between the two commodities (through trading or exchange of resources of factors) to a point B or C on the production contract curve where the output of one commodity increases without the reduction in output of the other.

And, if through trading and reallocation of factors, the two firms move to any point between B and C on the contract curve, this economy can move from a point not on the contract curve to a point on the contract curve and expand its output of either or both commodities. Once on its production contract curve, the economy can only increase the output of either commodity byreducing the output of the other. It is clear that if we make a move form point B to point C, it is impossible to increase the output of either commodity without reducing the output of the other; here the economy increases its output of commodity x but its output of commodity y falls. For an economy of many commodities and many factor inputs, the general equilibrium of production occurs where the marginal rate of technical substitution (MRTS) between any pair of factor inputs is the same for all commodities and producers using both inputs.

9.4 Output Efficiency

Output Efficiency occurs where the combination of products actually produced is such that there is no alternative combination of products that would raise the welfare of one consumer without reducing the welfare of another.

Both the exchange efficiency and the production efficiency criteria must hold in order for this criterion to be met. The combination of outputs produced according to this criterion is distributed between consumers according to the exchange efficiency criterion, and the economy is operating with production efficiency.

Pareto Optimality is the result of rational economic behaviour on the part of producers, consumers and owners of factors of production in a perfectly competitive economy. Although we don't have the scope to examine the underlying theory here it can be shown that Pareto Optimality will be achieved if all markets are perfectly competitive and in equilibrium.

It is important to realise that, whilst Pareto Optimality is the outcome in an economy that meets each of the three efficiency criteria listed earlier, this does not mean that there is only one 'optimal' allocation of resources. A Pareto efficient economy results in the maximisation of aggregate economic welfare for a given distribution of income and a specific set of consumer preferences. A shift in income distribution changes the incomes of individual consumers. As their incomes change, so too will their preferences, as their demand curves for various products shift to the left or right. This will result in a different equilibrium point in the various markets that make up the economy. Every alternative distribution of income or set of preferences is characterised by a different Pareto Optimum. Thus, since there is an infinite number of different ways in which income can be distributed, there is also an infinite number of different Pareto Optimal equilibriums.

Obviously, in practice, no economy can be expected to attain the Pareto Optimum position. Moreover, the Pareto principle is of little practical use as a policy tool since it is rarely possible to devise a policy that makes someone better off without making someone else worse off. Nevertheless, it is an important concept in the neo-classical tradition of economics and integrates much of the theory. It is also a standard against which economists can explore the real world, where making one person better off almost invariably means making someone else worse off.

10 Pareto Efficiency and Perfect Competition

We now turn to the concept of Pareto Optimality, named after the economist Vilfredo Pareto. It is a concept that you will find recurring frequently in the economics literature. The main proposition of Pareto Optimality can be summed up as follows.

An economy is in a Pareto Optimal state when no further changes in the economy can make one person better off without at the same time making another worse off.

You may immediately recognise that this is the socially optimal outcome achieved by a perfectly competitive market referred to above. It can be shown that an economy will be Pareto Optimal when the economy is perfectly competitive and in a state of static general equilibrium. The intuitive case for this is based on the fact that prices reflect economic values in a competitive market. If a unit of goods or services could produce more or bring greater satisfaction in some activity other than its present use, someone would have been willing to bid up its price, and it would have been attracted to the new use.

When this price system is in equilibrium, the marginal revenue product, the opportunity cost, and the price of a resource or asset will all be equal. Each unit of every good and service is in its most productive use or best consumption use. No transfer of resources could result in greater output or satisfaction.

This can be examined more formally in terms of three criteria that have to be met for a market equilibrium to result in Pareto Optimality. These are that there should be: exchange efficiency, production efficiency and output efficiency.

In a perfectly competitive system, the factors and commodities markets will achieve an economically efficient outcome.

1. **Efficiently in Exchange**: In perfect competition all consumers face the same prices; as a result all consumers in equilibrium equate their MRSxy to product price-ratio, i.e.

$$MRS^A_{xy} = MRS^B_{xy} = \frac{P_x}{P_y}$$

Exchange efficiency occurs when, for any given bundle of goods, it is not possible to redistribute them such that the utility (welfare) of one consumer is raised without reducing the utility (welfare) of another consumer.

A simple example of this is where there are two individuals, one with a loaf of bread, the other with a block of cheese. Both can be made better off by exchanging bread for cheese. An efficient exchange system will allow exchange of bread and cheese to take place until neither party can be made better off without one of them becoming worse off.

In a multi-product, multi-consumer economy, exchange is far more complex and involves the use of money to facilitate exchange. However, the principle is the same. So long as products can be reallocated to make one person better off without making another worse off, the economy is operating sub-optimally from the point of view of exchange efficiency. In a perfectly competitive market, exchange will occur until this criterion is met.

Exchange efficiency alone does not necessarily result in Pareto Optimality. This is because it relates only to a specific bundle of goods. It may be possible to make one or more individuals even better off - without making any one else worse off - by

altering the bundle of goods produced in the economy. This could involve raising the total volume of goods produced, as well as altering the combination of goods produced.

2. **Efficiency in Production:** Efficiency in production requires that MRTS between any 2 factors be the same for all the commodities. With reference to 2 products, x and y and 2 factors, L and K, in our model, this condition may be expressed as Profit maximizing firms are in equilibrium, with respect to a product (say x) where

$$MRTS_{LK} = \frac{W}{R}$$

When factor market is perfectly competitive W and R are each the same for all the firms using L and K, Therefore:

$$MRTS^X_{LK} = MRTS^Y_{LK} = \frac{W}{R}$$

Production efficiency occurs when the available factors of production are allocated between products in such a way that it is not possible to reallocate the production factors so as to raise the output of one product without reducing the output of another product.

This is analogous to *technical or production efficiency* at the level of the firm. What is being said here is that there are many situations in which it is possible to raise the total output in an economy by simply reallocating factors of production at no additional cost. This is because factors of production are more productive in some uses than they are in others. In a competitive economy, producers bid for factors of production until they are reallocated to their most productive use.

For example, if there is a lot of unproductive, low-wage labour employed in the agricultural sector and labour shortages in the industrial sector where labour productivity is potentially high, factory owners will bid up the price of labour and draw labour from the agricultural sector into the industrial sector. This could significantly raise output in the industrial sector without having a negative impact on output in the agricultural sector. So long as factors of production can be redistributed in a way that increases the output of one product without reducing the output of others, the economy is operating sub-optimally in terms of production efficiency.

3. **Efficiency in Production and Exchange:** We know

$$MRS_{xy} = \frac{P_x}{E}$$

In perfect competition, a profit maximizing firm sets its optimum combination of output Where

$$MRT_{xy} = \frac{\Delta Y}{\Delta X} = \frac{MC_x}{MC_y}$$

We also know that in a perfectly competitive market $MC_x = P_x$ and $MC_y = P_y$.Therefore,

$$MRT_{xy} = \frac{MC_x}{MC_y} = \frac{P_x}{P_y}$$

Since

$$MRS_{xy} = \frac{P_x}{P_y}$$

Therefore,

$$MRS^A_{xy} = MRS^B_{xy} = MRT_{xy} = \frac{P_x}{P_y}$$

Thus all marginal conditions of efficiency are met in the perfectly competitive framework.

11 Interlinkages between the Economy and Environment

We have to understand the importance of environment for the economy. Our economic system provides us the desired material goods and services for all our needs. This economic system can't survive without the support of environment around us which includes various communities of insects, plants, animals and different other natural resources. The interrelationship and influence in a community of organisms and natural resources on each other is called an ecosystem. A pond ecosystem is an example of a very small ecosystem where everything from shallow water to various plants, fishes, frogs, rocky or muddy bottom, various insects etc. are interrelated and interdependent.

This pond may provide so many things like water, fishes, algae, other plants etc. for the economy to be used for various purposes. If water charging in the pond or the aquatic life or anything else is badly affected it will also inversely influence economic activities of the people depending upon this pond. Similarly environment provides us the raw materials which are transformed into numerous commodities through various economic processes. Simultaneously it also provides direct services to all of us, by providing oxygen, air, water, sunlight, scenic beauty etc. The uninterrupted supply of these environmental goods and services is necessary for the existence of our economic system.

But the conventional economics textbooks often ignore the economy-environment interrelationship, without considering this relationship an economic model or the picture is incomplete and misleading.

The basic economic processes of extraction (for example mining of iron ore from iron mines), processing/fabrication (converting iron ore into steel and automobile) and consumption (using the automobile), all involve the generation of waste product that ultimately goes back into the environment (air, water or onto the land).

In most of our economic models and hence the textbooks, markets try to solve the problems of finding the efficient and right amount of production and consumption in terms of minimization of costs directly involved in the process of production and maximization of utilities in the consumption of market goods. But they do not try to find the right or of socially desirable amount of waste or the pollution. Our environment also acts upon the waste being produced by us. This natural process helps to clean up and recycle the waste to be used again. But there is a capacity of nature to absorb the waste or the pollution. If the pollution crosses this capacity it starts affecting the producers as well as consumers by affecting the supply of environmental goods. As for the survival of present generations the production of market goods is necessary similarly for future generations the protection of environment is also necessary. Hence in environmental economics an important question is to find the right balance between protection and use of environment.

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

11.1 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.

11.2 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.

11.3 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.

11.4 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.

11.5 Environment provides resources to the economy

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

ment 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.

11.6 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.

The environment, both biological and physical, is the source of all natural resources. Some natural resources are renewable (e.g., water, biological resources) while others are non renewable (e.g., geological deposits). The interlinkages between the economy and the environment are summarized in the **Figures 2 and 3**.

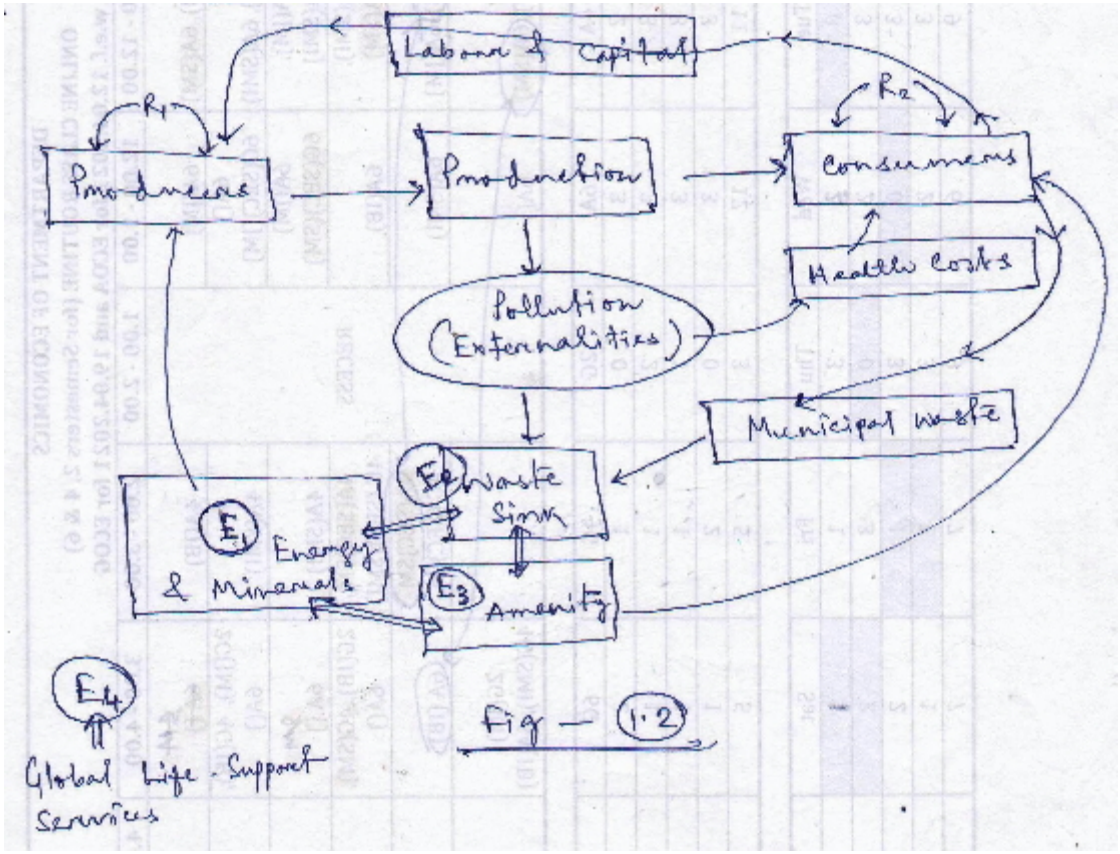

Figure 2: Circular Economy

As we can see the environment's first role is as a supplier of resources. Secondly it acts as a sink or a receptor for waste products. These wastes may result directly from production, as already mentioned or from consumption. When an individual puts out their garbage, or when they drive to work, they are contributing to this form of waste. Finally the environment also serves as an amenity these include scenic beauty, recreation and other aesthetic values offered by the environment.

Environment can be acknowledged as fulfilling four basic welfare economic functions:

- (1) amenity values;
- (2) a resource base for the economy;
- (3) a sink for residual flows;
- (4) a lifesupport system.

Pearce and Turner (1990) present these four functions and their interlinkages within the context of "The circular economy" in their textbook on environmental economics, but the conceptual and theoretical understanding here differs fundamentally from that of industrial ecology.

The circular economy from the environmental economics perspective is based on a material balance principle (Kneese et al. 1970), which implies that all material flows need to be accounted for, although it will be the economic values, not the physical flows, that guide their management.

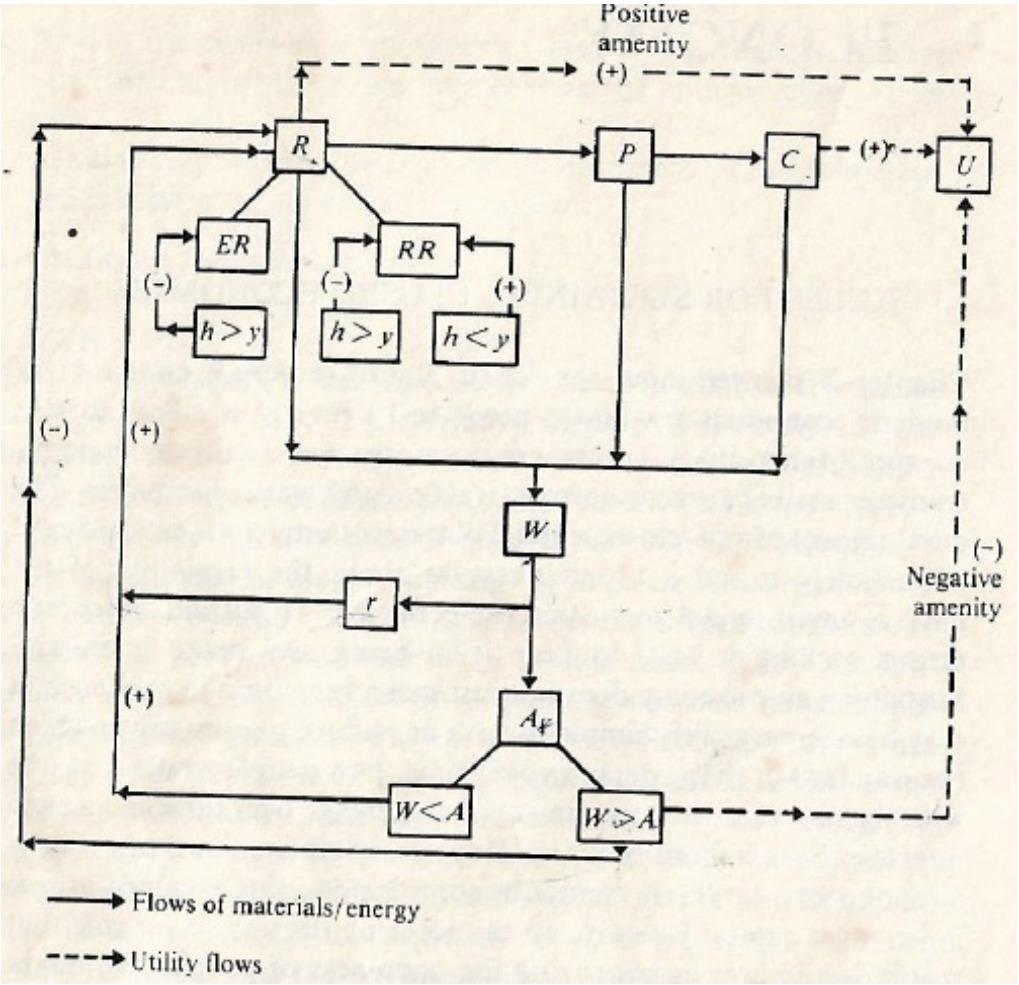

Figure 3: Circular Economy (Pearce & Turner, Ch: 2)

Here, *R = Resource, ER = Exhaustable Resource, RR = Renewable Resource, P = Production, C = Consumption, U = Utility, h = harvest rate, y = yield rate, w = waste, r = recycling, A = Amenities.*

Figure 3 shows the linkages between the four economic functions of the environment – and underlines the significance of the circular economy. Residuals that are discharged to the environment do not only have the potential to cause harm (if waste exceeds assimilative capacity) by affecting amenity values and the lifesupport function, they have also been lost from the point of view of the economic system. This loss of residual materials from the economic system can be postponed for non-renewable resources if a circular economy that promotes recycling and reuse is instituted.

However, there is the additional issue of minimisation. Some environmental economists argue that the input of materials and resources to the economy should be kept at a minimum and that a minimisation approach is a necessary prerequisite to the circulation of residuals. The argument for reducing the scale of material circulation lies with the second law of thermodynamics and the concept of entropy.

As suggested by S. Baker, we can conclude that to improve the analysis of environmental economy interactions, the empirically relevant and up-to-date knowledge of ecological and natural sciences needs to be used and integrated into environmental economics in a more systematic way.

Summary 1 *The economy and the natural environment are linked to each other in four ways, with the environment supplying material and energy resource inputs, waste assimilative capacity, amenity, educational and spiritual values, and global life support services to the economic process. These interlinkages are dynamic, in that they are continually changing. The first and second laws of thermodynamics partially govern the interrelationships, although economists disagree on how important the two laws are in terms of their implications for future economic activity.*

12 Natural Resources

The term "resource" means anything that we use from our environment to achieve our objective. For example, we require bricks, cement, iron, wood etc. to construct a building. All these items are called the resources for construction of building. A resource can be defined as any natural or artificial substance, energy or organism, which is used by human being for its welfare. These resources are of two types: **(a) Natural resources** and **(b) Artificial resources**.

All that the nature has provided such as soil, air, water, minerals, coal, sunshine (sunlight), animals and plants, etc., are known as natural resources. Human being uses these directly or indirectly for survival and welfare. The resources, which have been developed by human being during the growth of civilization, are called artificial resources. For example, biogas, thermal electricity, plastics, etc are manmade resources.

These man-made resources are generally derived from some other natural resources. For example, plastics and many other chemical products are ultimately derived from the natural resource of petroleum.

12.1 Classification of Natural Resources

The air we breathe and the light we get from the sun are available in unlimited quantity. But what about coal, forest, and petroleum? The stock of these resources is limited. The quantity of these resources is depleting day by day.

1. Natural and Artificial (e.g. electricity)
2. Exhaustible and Inexhaustible(e.g. solar energy, wind, rainfall, tidal energy)
3. Renewable and Non-renewable (e.g. wind, water, forests) (e.g. coal, petroleum, iron, biological species)

12.1.1 Exhaustible Resources

On the other hand, there are some resources, which are available in limited quantities and are going to be exhausted as a result of continues use. These are called exhaustible resources. For example, the stock of coal in the earth is limited and one day there will be no more coal available for our use. Petroleum is another important exhaustible resource.

12.1.2 Inexhaustible Resources

The resources which cannot be exhausted by human consumption The resources which cannot be exhausted by human consumption and other uses, are called inexhaustible resources. These include energy sources like solar radiation, wind power, water power (flowing streams) and tidal power, and substances like sand, clay, air, water in oceans, etc.

12.1.3 Renewable Resources

Some of the exhaustible resources are naturally regenerated after consumption and are known as renewable resources. e.g. The living beings (both animals and plants) reproduce and can thus, replace the dying or killed individuals. However, if the consumption of these resources exceeds the rate of regeneration they may also get totally exhausted.

Some examples are fresh water, fertile soil, forest (yielding wood and other products), vegetation, wildlife, etc.

12.1.4 Non-renewable Resources

The resources, which cannot be replaced after the use, are known as nonrenewable Resources. These include minerals (copper, iron etc.) fossil fuels (coal, oil etc.).Even the wildlife species (rare plants and animals) belong to this category.

12.2 Conservation of Natural Resources

As the human population is continuously growing the consumption of natural resources is also increasing. With the increasing industrialization and urbanization of the modern human society, the use of all the resources is rising. If they are not properly used and well managed, a serious scarcity will result. Therefore we need to conserve the natural resources. This will also upset the ecological balance. Conservation is the proper management of a natural resource to prevent its exploitation, destruction or degradation.

Conservation is the sum totals of activities, which can derive benefits from natural resources but at the same time, prevent excessive use leading to destruction or degradation.

12.2.1 Need for Conservation of Natural Resources

We know that nature provides us all our basic needs but we tend to overexploit it. If we go on exploiting the nature, there will be no more resources available in future.

Sustainable Natural Resource Management:

1. We are to use resources carefully, as they are limited
2. Resources should last for generations (long run perspective).
3. There should be equitable distribution of resources; and resources should not be limited to rich & powerful people.
4. We are to keep in mind and to address environmental issues while extracting natural resources.
5. There must be safe disposal of waste when extracted or used.

There is an urgent need to conserve the nature. Some of the needs are:

1. To maintain ecological balance for supporting life.
2. To preserve different kinds of species (biodiversity).
3. To make the resources available for present and future generation.
4. To ensure the survival of human race.

13 Sustainable Development

More than one hundred definitions of sustainable development exist, but the most widely used one is from the World Commission on Environment and Development, presented in 1987. It states that sustainable development is "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Sustainable development promotes the idea that social, environmental, and economic progress are all attainable within the limits of our earth‘s natural resources. Sustainable development approaches everything in the world as being connected through space, time and quality of life.

In terms of the world being connected by space, consider the following: Pesticides sprayed in Chile have the potential to harm fish stocks off the coast of Japan. The air pollution we emit in Los Angeles affect the quality of air in Asia. On the flip side, clean air practices on one continent will positively impact air quality across the ocean.

The earth‘s connection to time is demonstrated in how we, today, are either benefitting or suffering from the choices of our grandparents and other ancestors. Their decisions about how to farm their land, for example, continue to impact the agricultural practices of today. Looking to the future, the economic choices we make and policies we endorse today will be the ones affecting our children and grandchildren as adults.

Sustainable development constantly seeks to achieve social and economic progress in ways that will not exhaust the earth‘s finite natural resources. The needs of the world today are real and immediate, yet it‘s necessary to develop ways to meet these needs that do not disregard the future. The capacity of our ecosystem is not limitless, meaning that future generations may not be able to meet their needs the way we are able to now.

Some of the more common examples of sustainable development practices are:

1. Solar and wind energy. Energy from these resources is limitless, meaning we have the ability to eliminate dependence on non-renewable power sources by harnessing power from renewable resources.

2. Sustainable construction. Homes, offices and other structures that incorporate recycled and renewable resources will be more energy efficient and stand the test of time.

3. Crop rotation. Many farmers and gardeners are using this method as a chemical free way to reduce diseases in the soil and increase growth potential of their crops.

4. Water fixtures. Water conservation is critical to sustainable development, and more and more products are available that use less water in the home, such as showers, toilets, dishwashers and laundry systems.

The world‘s resources are finite, and growth that is unmanaged and unsustained will lead to increased poverty and decline of the environment. We owe it to future generations to explore lifestyles and paths of development that effectively balance progress with awareness of its environmental impact. In order to preserve the future, we must appreciate the interconnectedness between humans and nature at all levels. Sustainable development practices can help us do this, and through education and building awareness, preserving the future is within everyone‘s reach.

13.1 Economics of Sustainable Development

’Sustainable Development’ has become a political buzzword since the 1992 Rio Conference on the Environment, organised by the United Nations. But what exactly does it mean? That is a difficult question to answer since sustainable development (SD from now on)

means different things to different people: people place varying emphases on multiple aspects of the rather vague notion which is SD.

The best-known definition is that given by the Brundtl and Commission in 1987 (WCED, 1987): development that meets the needs of present generations without compromising the ability of future generations to meet their own needs.

Another definition was offered by Asheim (1994): A requirement to our generation to manage the resource base such that the average quality of life we ensure ourselves can potentially be shared by all future generations.

Many people see sustainable development as in fact serving multiple goals - economic development, a better environment and a particular concern for the poor (Pearce and Atkinson, 1998). At the more general level, development is indeed viewed rather differently to growth, implying some progress in areas such as health and education, rather than just increasing incomes. Two common features of many definitions of sustainable development are equity across and within generations, but most of the economics literature on sustainability has emphasized the former.

Economists would say that SD is indeed principally an equity rather than an efficiency issue. However, the bigger the economic pie (broadly defined as total 'quality of life'), the more of it there is to go around, since other things being equal, economic growth raises the average level of well being. There is thus a potential complementarily between promoting both efficiency and equity. This view is controversial some would argue (e.g. Daly,1990, Meadows et. al 1992) that economic growth is in itself the cause of declining sustainability, since an expanding economic scale pushes increasingly against environmental constraints, threatening the operation of .the joint economic-environment system, whilst there is a view that increasing income has a weak impact on increasing well-being above some threshold level.

It is also possible to distinguish between the idea of sustain ability, namely the property whose performance can be maintained over time, and sustainable development the extent to which development can be sustained. In general, however, the terms "sustainable development" and "sustainability" are used interchangeably in economics, with each being about as contentious as the other. This chapter tries to pick out the main contributions that economists have made to the debate on sustainability, and on how we might measure it.

Why should we worry about the well-being of future generations?

Two lines of reasoning have emerged. The first takes a utilitarian approach, and says that social welfare is concerned with the discounted sum of well-being of all people in a society over time. What the discount the rate should be in calculating these present values is not something we have room to discuss here - the interested reader is referred to Sheraga and Sussman (1998) and Wietzman (1998). An alternative argument is that future generations have moral rights to a level of well-being, perhaps no less than ourown. This Kantian view is in philosophical opposition to the utilitarian view above..

Norton gives a good account of the issues involved in taking this position. Economics' views on what defines a sustainable development path for an economy over time may be divided into two broad groups. The first (the outcome approach) is concerned with how the economic process directly affects human wellbeing.

Well being is synonymous with the standard economic concept of utility or welfare of an individual. Hence, sustainability can be defined as the utility of a representative agent in any period t, $U(t)$ – taken to represent society's interests - to be non-declining for the rest of the from time t^* onwards.

$$\frac{\partial U\,(t)}{\partial t} \geq 0,\ \forall\ t > t^{*} \tag{1}$$

or that in any period t, the utility of that representative agent ($i.e., U(t)$) does not exceed the maximum sustainable level of utility ($i.e., U_m(t)$), depending on the economy's potential at time t (Pezzey and Toman, 2002):

$$U(t) \leq U_m(t) \tag{2}$$

Where, for time periods following on from time periods t:

$$U_m(t) = maxU \quad given \quad U(s) \geq U(t) \quad \forall\ s \geq t \tag{3}$$

Equation (2) says that SD occurs when utility per capita is not falling over time (this Means that constant utility equals sustainability, as well as rising utility). A variant on the outcome-based approach is to define SD in terms of the observable determinants of utility. In other words, if we know what factors affect utility - for example, the level of consumption and the level of environmental quality - then by examining changes in these factors we can infer whether a sustainable path is being followed according to Pezzey's definition.

A time path of consumption over time which is rising and then falling might be consistent with maximising the present value of social well-being, according to the utilitarian view, but would not be a sustainable path. There is thus a trade-off here between sustain ability and present-value maximising optimality. Note also that the outcome definition of sustainable development implies that it is the absolute level of consumption and environmental quality per capita that matters for well-being, not one's consumption/environmental quality relative to one's neighbours, implying that rising real incomes result in higher utility. For a theoretical discussion of this assumption, see Pezzey (1997); for a 'recent review of empirical evidence, see Blanch flower and Oswald (2004).

The second economic approach to defining sustainability focuses on maintaining the means .which are available to society to generate well-being or consumption, namely its resources. Resources consist of physical stocks and the technology which we use to exploit them. Economists have thought about SD from this viewpoint in terms of the concept of capital. Four forms of capital may be distinguished (Hanley and Atkinson, 2003).

1. Man-made, or produced, capital, Km: This is the 'capital' that most economics students are familiar with. It comprises the results of past

production, as the excess of output over consumption. Km includes factories, machinery, roads, bridges, phone networks and satellites, and may be used up (depreciated) in the production of consumption goods and services. This depreciation needs to be offset with new investment or else the stock of Km will decline over time.

2. Human capital, Kh: Human capital is people, their skills and knowledge. The stock of Kh can also depreciate (e.g. if unemployed people lose their skills), and can be added to through training and education.

3. Natural capital, Kn: Natural capital comprises all gifts of nature, and so includes renewable and non-renewable energy and material resources, clean air and water, nutrient and carbon cycles and biodiversity. Natural capital can clearly be depreciated when, for example, a non-renewable resource such as oil is used up or when a species dies out. Investments in Kn would include forest replanting and re-stocking of fisheries.

4. Social capital, Ks: Recent attention has been directed towards the link between 'social capital' and sustainability, see World Bank (1997) for a discussion. Putnam (1993)

speaks of social capital as comprising certain features of social organisation -norms of behaviour, networks of interactions between people and between institutions and trust between people. This could be important for sustainability in several ways. First, it is argued that there is an 'economic pay-off from social capital whereby conditions favorable to economic growth are fostered by a climate of trust between agents (Knack and Keefer; 1997). Second, there could also be an 'environmental pay – off' whereby for example, strong communities ties help enforce-owner ship regimes and management systems for common property (Grafton, 2000).

Sustainable development, in what we might refer to as an 'opportunities approach' to the issue, can then be defined as a non-declining stock of capital over time. Or, we can link the two approaches, and we show later that a declining stock of capital means development is unsustainable by definition, so that these two approaches overlap, even if they are not identical.

13.2 Weak versus Strong Sustainability

Above, we noted that one way of conceptualizing SD is in terms of maintaining the economy's capital stock. Based on this idea, two different paradigms have developed. The first, which has become known as 'weak sustainability', requires that the real value of the total capital stock K, where ($K = Kn + Kh + Km$), be non-declining (note that we ignore social capital from now on). This permits natural capital to be run down (through using up oil stocks, say) so long as human and man-made capital are increased sufficiently. Maintaining the overall asset balance implies consuming merely the interest on this aggregate capital (Solow, 1986). This view clearly presumes that we can aggregate Kn, Kh and Km in the same units, and that they are substitutes for each other in terms of their capacity both to produce welfare and to maintain system functioning. The genuine savings (GS) and green net national product (GNNP) indicators of sustainability (discussed in the next section) both derive from this weak sustainability view of the world, and are part of an overall 'smooth substitution' approach that also underlies the utility-based definitions of sustainability.

An alternative view has been to maintain that SD requires that some part of the stock of Kn itself has to be prevented from declining. This view has been called 'strong sustainability', and derives primarily from the view that reductions in Kn cannot. be substituted for by increases in Kh, Km or any other forms of capital (Norton and Toman, 1997). Support for the concept of strong sustainability is also based on a view that ecological systems are characterised by non-linearities and discontinuities, which means that the welfare losses from declines in Kn, both present and future, are hard to predict. In other words, environmental limits matter, and breaking these limits is not compatible with long-term system stability. Strong sustainability requires the physical protection of absolute levels of environmental goods. This position has also been characterised by a focus on 'critical' natural capital. Critical natural capital is the subset of in which is either (i) essential for human survival, and / or (ii) not substitutable for by increases either in other elements of Kn, or in Kh or Km. An example might be the ozone layer, or the natural climate and atmospheric composition regulation functions of the earth.

Sustainability, from this perspective, is defined as no decline in this stock of critical Natural capital. If humans need the services of ecosystems, it is important to maintain these ecosystems in a functioning state. This in turn means protecting their natural (ability to withstand shocks), which may be achieved by ensuring that keystone are

species are preserved.

Table 1.1 below (adapted from van Kooten and Bulte, 2000) gives some more detail on the differing worldviews of weak and strong sustainability, and the neoclassical/ ecological economies viewpoints with which they are respectively associated

Table 1.1 Sustainability Rules

Weak sustainability – the Neo-classical Economics view

1. Focus marginal analysis as the nexus for decision making – absolute scale is of little relevance
2. Monetary valuation of changes in natural capital
3. Discounting and present values are central to analysis; focus on efficient resource allocation over time
4. Prices provide crucial signals of relative security
5. Technological progress seen as major factor in growth over time
6. Utilitarian approach to values
7. Current generation ensures sustainability by passing on an undiminished stock of aggregate capital
8. Individual behaviour seen as being consistent social well-being, so long as enforce property rights
9. Economics focus on the steady state internal dynamic behaviour and management of natural resources

Strong sustainability – the view from ecological economics

1. Focus on scale of matter – energy throughput
2. Monetary valuation down played
3. Discounting generally opposed; focus on fair resource allocation over time and the rights of future generations
4. Prices unreliable due to widespread externalities
5. Technological progress not seen as a cure-all solution, but as something which poses environmental problems in and of itself
6. Rights-based approach to values
7. Current generation needs to safeguard stock of natural capital for the future
8. Need for government intervention in terms of managing the scale and manner of economic activity and environmental impacts
9. Focus on threshold effects, uncertainty, irreversibility‘s and resilience.

14 Summary: Welfare Economics

A partial equilibrium analysis versus general equilibrium analysis

1. Partial Equilibrium Analysis Studies the behavior of individual decision making units and individual markets, viewed in isolation. For example, producers maximize profit subject to their production technology and resource constraints; likewise, consumers maximize utility subject to their taste and budget constraints. Similarly, changes in a single market are examined in isolation from other markets. This approach to economic analysis is called the partial equilibrium analysis. The advantage of this is that it permits the analyst to focus upon one thing at a time and thus allays the confusion that can arise if all the things are considered together.

2. The partial equilibrium analysis does not take into account the inter-connections that exist between an individual economic unit and the rest of the economy. These inter connections are taken care of under the generic assumption of certain paribus. In other words, in partial equilibrium analysis we study utility or profit maximizing behavior and decisions in each segment of the economy as if they were independent of the other segments of the economy.

3. A general equilibrium exists when all markets in an economy are in simultaneous equilibrium. It seeks to determine the equilibrium of an economy by analyzing the behavior of all interconnected and interdependent economic units and segments. Therefore general equilibrium analysis is concerned with the determination of equilibrium in all markets simultaneously.

General equilibrium in exchange

1. The general equilibrium of exchange occurs at a point on the contract curve where the marginal rate of substitution between the two goods (MRS_{xy}) of the two individuals is the Same. The exchange equilibrium cannot be at a point in the Edgeworth Box Which is not on the contract curve. This is because at a point which is not on the contract curve indifference curves of two individuals intersect each other and therefore in original rate of substitution (MRS_{xy}) are not equal to each other.

$$MRS^A_{xy} = MRS^B_{xy}$$

2. Utility possibility curve is derived from consumption contract curve. It shows the various combinations of utilities received by individuals A and B. When the economy is in general equilibrium. It is the focus of maximum utility for one individual for any given level of utility for the other individual.

General Equilibrium in Production

1. The economy is in general equilibrium of production when it is on its production contract curve.

2. Production contract curve is the focus of tangency points of the isoquants for x and y at which the MRTS of labour for capital is the same in the production of x and y. That is, the economy is in general equilibrium of production when

$$MRTS^X_{LK} = MRTS^Y_{LK}$$

3. The PPF curve depicts the several combinations of commodities x and y that the economy can produce by fully utilizing all of the fixed amounts of labour and capital with the best technology available.

4. The amount of commodities y that the economy must give up, at a particular point on the PPF, so as to release just enough labour and capital to produce one additional unit of commodity x, is known as the marginal rate of transformation of x and y (MRT_{XY}). This is specified by the absolute value of the slope of the PPF at that point.

General equilibrium in exchange and production

In this module we examine the simultaneous general equilibrium in exchange and production. We list the major assumptions:

- There are two factors of production, labour (L) and capital (k), which are perfectly homogeneous and divisible. The total endowment of each factor of production in the economy is fixed.
- There are two commodities, x and y produced in the economy; each commodity is homogeneous and divisible. The production function of x and y exhibit constant returns to scale. Further, the isoquant maps of both x and y are well behaved, i.e., downward sloping and convex to origin, implying a diminishing marginal rate of technical substitution (MRTS).
- There are two consumers, A and B, whose preferences are shown by the ordinal indifference curves which are downward sloping, convex to origin.
- The goal of each consumer is utility maximizationsubject to his income constraint.
- The goal of each firm is profit maximization subject to technological constraint.
- The factors of production are owned by the consumers.
- There is full employment of factors of production and all incomes received by their owners,A and B are spent.
- Both product and factor markets are perfectly competitive.

For the economy to be Simultaneously in general equilibrium of production and exchange, the marginal rate of transformation of x for y in production must be equal to the MRS of substitution of x for y in consumption for individuals A and B. That is,

$$MRT_{XY} = MRS^{A}_{xy} = MRS^{B}_{xy}.$$

Geometrically, this corresponds to the point on the contract curve for exchange at which the common slope of the indifference curve of the two individuals equals the slope of the PPF at the point of production.

Welfare Economics and Pareto Optimality

1. Welfare economics studies the conditions under which the solution to the general equilibrium model can be said to be optimal. It examine the conditions for economic efficiency in the production of output and in the exchange of commodities, and for equity in the distribution of income.

2. Pareto was the first economist who provided a positive criterion for comparing alternative states of the economy the paretian criterion says that if it is possible to improve the standard of atleast one person in moving from state 1 to state 2 without decreasing the standard of standard of anybody else, then state 2 is ranked superior to state by society. In other words it is desirable to move from state 1 to state 2 and this movement is considered as pareto improvement. However, when it is not possible to improve the standard of someone else.

3. The basic marginal conditions of pareto optimality may be summarized as follows:

   (a) Marginal condition of Exchange optimality – It means that the marginal rate of substitution (MRS) between any pair of goods must be the same for all the consumers.
   $$MRS^A_{xy} = MRS^B_{xy}$$

   (b) Marginal condition for production optimality – That is, the marginal rate of technical substitution (MRTS) between any pair of factors must be equal for all commodities and all firms.
   $$MRTS^X_{LK} = MRTS^Y_{LK}$$

   (c) Marginal condition in product Mix – It means that the marginal rate of transformation (MRT) between any pair of goods must be equal to the marginal rate of substitution for any pair of goods.
   $$MRS^A_{xy} = MRS^B_{xy} = MRT_{xy}$$

Social Welfare Function

1. A Social Welfare Function is a kind of aggregation of individual utilities. It gives a way to rank different allocations that depends only on the individual preferences, and it is an increasing function of each individual's utility.

2. In Classical utilitarian or Benthamite Social Welfare function approach, individuals derive utility from consumption or income. Utility is a cardinal concept and can be compared across, i.e.; The Weighted – sum – of – Utilities Welfare Function is given below:

   Where the weight are supposed to be numbers indicating how important each agent's utility is to the overall social welfare. It is natural to take each ai as being positive. John Rawe proposed another important social welfare function for maximizing social welfare the poorest individual's welfare must be maximized. This is known as the Rawlsian Social welfare function and is represented by:
   $$W = (u_1, u_2, \ldots . u_n) = min\{u_1, u_2, \ldots . u_n\}.$$

3. **Grand utility possibility Frontier:** This Utility possibility frontier shows the various combinations of utilities received by individuals A and B (i.e and) when the economy composed of individuals A and B is in general equilibrium or pareto optimum in exchange.

4. The highest point on the grand utility possibility frontier represents the maximum possible social welfare given the factor endowments, state of technology and preference scales of the individuals. This point is called the point of bliss given the constraints regarding factor endowments and the state of technology.

5. The **bliss point** is uniquely associated with the maximum social welfare and is pareto-efficient. It should, however, be noted that pareto-efficiency is a necessary, but not sufficient condition, for social welfare maximization. That is, the marginal efficient conditions only give pare to efficiency requirements; but it alone do not guarantee a welfare maximum.

Market Failure : Presence Of Market Imperfections

1. Perfectly competitive markets are ideal as they guarantee maximization of social welfare. But, in the actual world, such markets are very hard to establish and maintain.Consequently, the contemporary world is described by a preponderance of imperfect markets.

2. Economic efficiency of general equilibrium in the framework of Pareto optimality can be attained through exchange efficiency, Production efficiency and allocative efficiency.

3. When market fail to reach optimum (conditions of Pareto optimality) the concept of market failure comes into picture. Some of the important reasons of market failure are:

   (a) Failure of competition
   (b) Imperfect information
   (c) Externalities
   (d) Existence of public goods.

4. All types of imperfect competition (monopoly), oligopoly, monopolistic competition) leadsto misallocation of productive resources and thus hampers the achievement of maximum social welfare.

Incomplete information

1. Imperfect information is the major source of market failure.In equitable access to information to buyers and sellers can create some imperfect competition type situations, this resulting into market failure.

2. Government intervention may then be required to make information available equally to each participant in the market.

3. All the economic activities in the real world take place under the uncertain environment.

4. Uncertainty leads to inefficient outcomes.

5. Imperfect information or asymmetric information problem results in adverse selection due to hidden actions and hidden information.

6. Whenever a person seeks to have access to the missing information, he has to bear transaction cost in terms of search cost, bargaining cost, litigation cost etc.

7. The principal-agent framework highlights the problems encountered due to asymmetric information.

8. Signaling, screening, incentive creation, legislative measures etc. are some of the solutions that help get rid of the problem of information asymmetry.

9. Efficiency wage model is an application of asymmetric information in the principal-agent framework.

Externalities

1. Externality is one of the main reason of market failure. The major source of inefficiency lies in the existence of externalities. As externality arises when a person engage in an activity that influences the well being of another individual and get neither pays or receivers any compensationfor these effects.

2. Externalities (positive or negative) are borne by peoplewho are not directly involved in the market exchanges. Thus, an externality is a divergence between private costs and social costs or between private benefits and social benefits when externalities are present, the outcome of a competitive market is unlikely to be pareto efficient.

Public Goods

Another source of inefficiency lies in the existence of public goods. Public goods have two important characteristics (i.e. non-rival and non – exclusive).

Public good that are non – exclusive (i. e, it is impossible to limit the benefit to only those paying for it) lead to a free rider problem . Government feels that it is its responsibility to provide public goods like street lights, parks, national highways, etc. Hence, the optimal distribution of public good becomes a problem.

Hence, modern governments all over the world now intervene in market in various ways. The government role can be *distribution stabilizing* or *regulatory*. Government intervention is justified in situations characterised by the existence of inequitable access to information, common property resources, public goods and externalities.

Market with Incomplete Information

1. All the economic activities in the real world take place under the uncertain environment.

2. Uncertainty leads to inefficient outcomes.

3. Imperfect information or asymmetric information problem results in adverse selection due to hidden actions and hidden information.

4. Whenever a person seeks to have access to the missing information, he has to bear transaction cost in terms of search cost, bargaining cost, litigation cost etc.

5. The principal-agent framework highlights the problems encountered due to asymmetric information.

6. Signaling, screening, incentive creation, legislative measures etc. are some of the solutions that help get rid of the problem of information asymmetry.

7. Efficiency wage model is an application of asymmetric information in the principal-agent framework.

Here, we have defined and explained the terms 'efficiency' and 'optimality' as they are used in welfare economics. We have also demonstrated that a perfectly functioning 'ideal' market economy would bring about an efficient outcome, but not necessarily an optimal one. However, it is clear that economies in practice do not satisfy the conditions of the ideal competitive economy that we described above. Markets are incomplete – there are many things that concern economic agents that are not traded in markets. Where they exist, markets are often not perfectly competitive.

Many producers and consumers operate with information that is not perfect. Government must exist and raise revenue for the supply of public goods. Often, consumption and production behaviour generates uncompensated external effects upon others. These 'failures' will result in inefficient allocations of resources.

Many of the services that the environment provides involve some kind of market failure, and hence the levels of provision in a market system will not be those corresponding to allocative efficiency. Much of resource and environmental economics is about devising ways to intervene in the market system so as to promote efficiency in the use of environmental services.