



Directorate of Distance & Continuing Education
Manonmaniam Sundaranar University
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B.A. ECONOMICS
(Third Year)

ENVIRONMENTAL ECONOMICS
(JMEC54)

Compiled by
Dr. K. AJITHA
Assistant Professor of Economics
Manonmaniam Sundaranar University
Tirunelveli – 627 012

Subject Experts:

Dr. D. Amutha Associate Professor and Head Department of Economics S.T. Mary's College (Autonomous) Thoothukudi	Dr. C. A. Sham Shankar Associate Professor and Head Department of Economics ST. Hindu College Nagercoil
Dr. S. Sarasudevi Associate Professor Department of Economics Rani Anna Government College for Women Tirunelveli	Dr. V. Raja Rajeswari Associate Professor Department of Economics Sri KGS Arts College Srivaikundam, Thoothukudi District
Dr. M. Neeladevi Associate Professor Department of Economics V.O.C College Thoothukudi	Dr. P. Mary Thangam Assistant Professor Department of Economics Sarah Turker College (Autonomous) Tirunelveli
Dr. R. Rajan Babu Assistant Professor Department of Economics ST. Hindu College Nagercoil	Dr. V. Arockia Amuthan Assistant Professor Department of Economics Nazareth Margoschis College Pillaiyanmanai, Thoothukudi
Dr. S. Sasikumar Assistant Professor Department of Economics ST. Xavier's College (Autonomous) Palayamkottai, Tirunelveli	Dr. G. Gnana Elpinston Assistant Professor Department of Economics Nesamony Memorial Christian College Marthandam

Course Coordinator:

Dr. G. Monikanda Prasad

Course Material Compiled by:

Dr. K. Ajitha

Assistant Professor of Economics

Manonmaniam Sundaranar University

Tirunelveli – 627 012

ENVIRONMENTAL ECONOMICS

Course Objectives:

1. To understand the theoretical basis of environmental economics.
2. To choose the relevant economic tools to improve environmental quality.
3. To describe the environment as a public good and market failure theories.
4. To doctrine the various methods of environmental valuation and its uses.
5. To know the regulation of pollution through economic instruments.

UNIT	CONTENTS
I	Fundamentals of Environmental Economics Definition, Scope and Significance – Environment – Economy Linkages – Material Balance Approach – Malthusian and Neo-Classical perspective of Environment – Sustainable Development – Environment Kuznets Curve.
II	Economics of Natural Resources Classification of Natural Resources – Scarcity and Measurement- Economics of Exhaustible Resources – Economics of Renewable Resources.
III	Market Failure Environment as a Public Goods – Tragedy of Commons – Externalities – Pigouvian Fee and Coase Theorem on Property Rights.
IV	Valuation of Environment Total Economic Value – Contingent Valuation Method – Stated Preference – Travel Cost Model – Hedonic Pricing – Economics of Sustainable Development – Green Accounting – Ecological Foot Print, Carbon Foot Print, Ecological Shadow.
V	Economics of Pollution Control Optimal level of pollution – Regulation of Pollution through Economic Instruments – Command and Control Approach.
Textbooks	
1. Karpagam. M, (2017), Environmental Economics – Third Edition, Sterling Publication Pvt. Ltd, Noida.	
2. Nick Hanley, Jason Shogren and Ben White, (2013), Introduction to Environmental Economics, Second Edition, Oxford University Press, Oxford.	
3. Eugene. T, Environmental Economics, Oxford University Press, New Delhi (2014).	
4. Hanley N, Shogren JF, White B” Environmental Economics in Theory and Practice”, 2 nd Edition, Palgrave Macmillan, 2007.	
5. Kolstad, Charles D, (2000), Environmental Economics, New York: Oxford University Press.	

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UNIT – I

FUNDAMENTALS OF ENVIRONMENTAL ECONOMICS

1.1. Introduction

Earth is the only planet, so far known to have an environment that can sustain life. It has all the physical conditions necessary for the origin and survival of human beings, animals and plants. The environment provides us food, clothing, shelters, medicines, raw materials and all other human needs including aesthetic pleasure and a liveable atmosphere. Natural resources, both renewable and non-renewable, form the basis of our very existence on this terrestrial globe. It is an undisputable fact that natural resources also form the basis of all our scientific advancements technological progress, genetic engineering, improvement in agriculture and industrial advancement. Economics, in general, studies the resource getting and resource using activities of human beings in the environment to ensure general welfare to the society at large. Hence there is strong relationship between environment and economics. For a long time, humanity cherished with the philosophy that it was the master of the environment. The whole humanity is facing so many environmental problems which have economic and social dimensions.

1.2. Definition

Environmental Economics can be defined as, “That part of Economics which deals with the inter relationship between environment and economic development and studies the ways and means by which neither is the former is impaired, nor is the latter impeded”

An Environmentalist is, “A person whose Centre’s his or her political philosophy on the need to preserve the natural environment and to halt or reverse the damage created by industrial development and pollution”.

1.3. Scope of Environmental Economics

The environment has got a very close relationship with economics. This relation deals with the welfare of the society and the growth theories of economics.

1. Economic Growth and Environmental Balance:

Economic growth and environmental balance do not go together. They both oppose each other. To achieve a higher economic growth, resources

have to be exploited and environment has to be harmed. Environment balance can only be obtained, if resources are not exploited and pollution is not formed. This leads to low economic growth. The only solution is controlling the scale of pollution and optimal use of the resources. Now nations are concerned about sustainable development, i.e., use of the resources without endangering the future generations. A cost benefit analysis must be undertaken to watch the positive and negative points of any action. It is only when the benefits are greater than the costs, the project is undertaken.

2. Pollution Control and Environment:

Economic activities give rise to pollution. This pollution has a serious impact on the environment and the society. It is the society that feels the harmful effects of the pollution. Pollution today has a very high clean up and control cost which ultimately has to be borne by the consumer. The consumer also gets poor living conditions and environmental quality.

3. Conservation of Resources:

The environment is the provider for all the materials needed by the man i.e., air, water, minerals, timber, shelters, food, etc. These resources can be classified as renewable (forest, crops, etc) and non-renewable (coal, oil, iron, etc). Optimal use of these resources is a must and wastage must be totally avoided because without these resources, man cannot carry on any economic activity.

4. Limits to Growth:

Economic growth often creates the need for further economic growth for the following reasons:

- (i) Governments rely on economic growth to avoid problems of unemployment.
- (ii) Governments are commonly judged by their ability to raise standards of living or to increase GNP.
- (iii) Technology damaged the natural ecosystems and created a so called "need" for more technology to overcome this damage.
- (iv) Industrial growth meant population growth which led to more growth.

1.4. Significance of Environment

We have to understand the significance 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 interrelationship¹, 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.

1.5. Linkage Between Environment and Economy

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

I. Environment in Economic Analysis:

Environmental issues are considered in the production and consumption analysis in economics. Green production and green consumption are 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.

II. Economics in Environmental Analysis:

Environment resources, their allocation and utilization are considered in the context of their economic cost benefit. The demand and supply, benefit and losses, equilibrium of environment resources all are analyzed in the context of economics. There are many environment theories which have developed with the integration of economic theories. These include environment resource planning, sustainable environment, development environment, input-output model, environment cost analysis, environment

policy, environment pricing, environment budgeting, environment fiscal analysis etc.

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

III. Environmental problems and their solution in Economies:

With the help of input-output analysis, cost benefit analysis, pollution tax and environmental subsidies, economics shows various ways and means to solve the environmental problems. Environmental problems are basically man-made and economics has solution for them. There should be no over utilization of natural resources. We should develop some basic standards for use of natural resources.

IV. Mutual Dependence:

There are environmental causes for economic problems and economic causes for environment problems. There is economic solution for environment problems and environment solution for economic problems. In the same way, environment theories are needed for economic theories and economic theories are essential for environment theories. Industrial and domestic wastes are the prime cause of water pollution and air pollution. Polluted water gets absorbed in land and creates land pollution. Economics has a solution for this. According to economics, air, land, water, river, ocean etc. are public goods which spread out pollution. We should control these polluted public goods.

V. Environment provides resources to the economy:

Environment provides land, water, air, energy resources, coal, oil, forests, minerals and metals and so many other natural resources which are essential for the economic development of the economy. It provides services which are directly used by the consumers i.e. air we breathe and water we drink as a liquid of life. It provides forests, water reservoirs, rivers etc. and wildlife sanctuaries which also play economic roles for the mankind.

VI. Environment assimilates the waste and provides utility:

Natural resources are input to the economic system and natural wastes are recycled. For example, trees dispose of their leaves, decompose and are converted into an organic fertilizer for plants. Whatever we use up for way of resources, must end up somewhere in that environment system and cannot be disappeared or destroyed. Environment takes the non-cyclical wastes and converts them back into harmless or ecologically useful products. It acts as a sink for all the waste products that are the result of the process of production and consumption. The environment is not a passive sink; it acts upon the waste products to clean up the environment.

1.6. Material Balance Approach

The environment has got a fixed amount of mass which takes the form of soil, plants, minerals, etc. This mass changes from one form to another due to environmental or manmade influences. For example, water takes the form of ice, snow, vapour, etc. no matter what be the shape, the entire mass of water in the environment does not change. Even if the water is split into oxygen and hydrogen, the total quantum of the elements is the same as that of the original water. The Material Balance Model studies the relationship between the environment and the economy. In this model, we assume that the economy is made up of the production sector and household sector. It is in the production sector where all the economic activities of production come together with the factors of production being used to produce a finite quantum of goods. The household sector on the other hand consumers the goods produced in the production sector. This sector is made up of the consumers in the economy.

Assuming the economy to be this simple, two sector model existing in the environment, the material balance model can be explained. This model follows the law of conservation matter which states that the mass of output and residual got from processing producing a commodity must be equal to the mass of all the inputs. This theory also assumes that there are no exports and that there is not stock accumulation or hoarding. The production sector uses R unit of raw material from the environment to produce F units of the

final product. While doing so it also produces W_1 amount of waste.

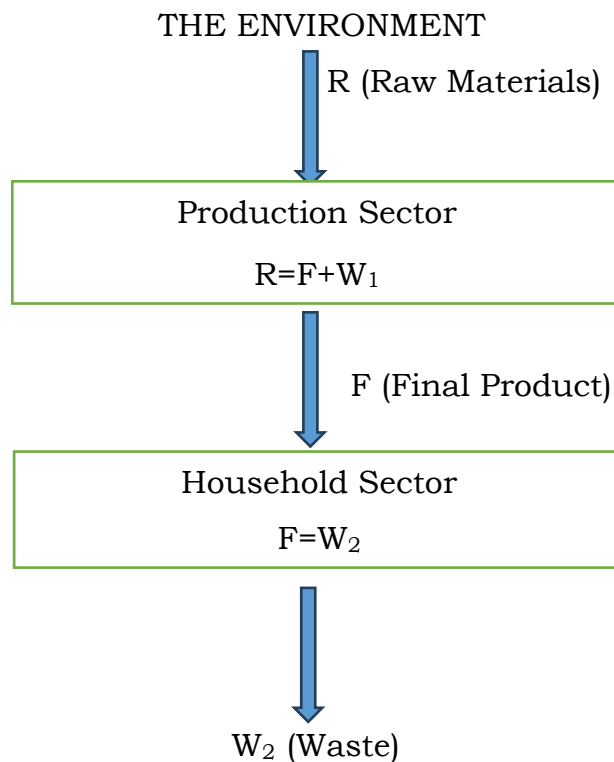
In the production sector, $R=F+W_1$

The house hold sector consumes all the F units which are produced in the production sector. While doing so, there is a lot of waste produced. This waste can be packaging, by products, etc. this entire amount is returned to the atmosphere producing W_2 units of waste.

In the household sector, $F=W_2$

Hence in the economy, $R = W_1+W_2$

The entire mass of inputs (raw materials) equals the entire mass of output (waste). This is the “Material Balance Model”.



Material Balance Model

1.7. Malthusian and Neo-Classical Perspective of Environment

The relationship between the economy and the environment has been a subject of continuous debate among economists. Two major schools of thought the Malthusian perspective and the Neoclassical perspective offer contrasting explanations regarding how population growth, resource use, and economic development affect the environment. The Malthusian view emphasizes natural limits and population pressure, while the Neoclassical

approach focuses on market efficiency and technological innovation as solutions to environmental problems.

Malthusian Perspective: The Malthusian theory was developed by Thomas Robert Malthus in his work “An Essay on the Principle of Population” (1798). Malthus argued that population growth tends to increase geometrically, while the growth of food and other resources increases arithmetically. As a result, population growth eventually surpasses the carrying capacity of the environment, leading to resource scarcity, famine, disease, and other natural checks. According to Malthus, nature imposes certain limits on human activities. When the population exceeds the available resources, environmental degradation becomes inevitable. Deforestation, soil erosion, depletion of minerals, and loss of biodiversity are seen as the consequences of overpopulation and overexploitation of natural resources. Malthus believed that only preventive measures (such as moral restraint and family planning) or positive checks (like famine and disease) could restore the balance between population and resources. Thus, the Malthusian perspective presents a pessimistic view of the environment, emphasizing that unchecked population growth leads to ecological collapse and human suffering. It suggests that environmental sustainability can be achieved only through population control and limited use of natural resources.

Neoclassical Perspective: In contrast, the Neoclassical perspective of the environment emerged from mainstream economic thought, emphasizing the role of markets, prices, and technology in managing environmental resources. Neoclassical economists view the environment as a source of inputs for production and as a sink for waste, which can be efficiently managed through market mechanisms. According to this view, environmental problems such as pollution and resource depletion occur because of market failures that is, when the prices of goods do not reflect their true environmental costs. Therefore, environmental degradation can be corrected through proper valuation of environmental goods, property rights, pollution taxes, and regulations. The introduction of market-based instruments, such as carbon pricing and tradable pollution permits, is seen as an effective way to ensure efficient and sustainable resource use. Neoclassical economists believe that

technological progress and innovation can offset the scarcity of natural resources. They argue that human-made capital can often substitute for natural capital, allowing continuous economic growth without necessarily depleting environmental resources. This idea is reflected in the Environmental Kuznets Curve (EKC) hypothesis, which suggests that environmental degradation first increases with economic growth but eventually declines as income levels rise and societies demand cleaner technologies.

In conclusion, both the Malthusian and Neoclassical perspectives offer valuable insights into the relationship between economic activity and the environment. The Malthusian approach emphasizes the need to recognize the finite nature of environmental resources and the impact of population growth, while the Neoclassical approach highlights the role of economic incentives and innovation in achieving environmental sustainability. A balanced approach that combines population control, technological advancement, and sound environmental policies is essential for ensuring a sustainable relationship between humans and nature.

1.8. Sustainable Development

Sustainability translates into the ethical concern for future generations and the need to incorporate this concern into current planning and decision making of economic activities. The concern for future generation affects the use of environmental resources in current production and also the current decision-making process. There are various parameters through which sustainability issues can be comprehended and one of them is through our understanding of different consumption patterns. Utility functions where consumption is the only argument, and where utility increases with consumption is a standard proposition to address intertemporal distribution issues. The idea of sustainability as non-declining consumption is the concept of sustainability that is most widely used in economic analysis. However, constant consumption for indefinite time period into the future, at any rate other than zero, satisfying various constraints of social welfare maximization problem might not be sufficient to explain and address sustainability issues in totality.

The six core concepts of sustainability. The following core concepts of sustainability define a sustainable state as where:

- 1) The utility or consumption is non-declining through time.
- 2) The resources are managed so as to maintain production opportunities for the future.
- 3) The natural capital stock is non-declining through time.
- 4) The resources are managed so as to maintain a sustainable yield of resource services.
- 5) The minimum conditions for ecosystem resilience are satisfied through time.
- 6) The consumption approach to environmental sustainability, where consumption needs to be optimized over time and space.
- 7) Consensus building and institutional development are considered imperatives for sustainable development.

1.8.1. History of Sustainable Development

The concept of sustainable development formed the basis of the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. The summit was the first attempt to form action plans and strategies for moving towards sustainable development at global level. It was attended by over 100 Heads of State and representatives from 178 national governments. The Summit was also attended by public representatives from a range of other organizations. Sustainable development was first listed as the solution to the problems of environmental degradation the Brundtland Commission in the 1987. This report investigated the various concerns raised in previous decades like severe and negative impacts of human and unsustainable patterns of growth and development. The concept of sustainable development received its first major international recognition in 1972 at the UN Conference on the Human Environment held in Stockholm. Though this term was not used exactly as such but the concept of development and environment management in mutually beneficial and interdependent way originated in this conference. World leaders recognized sustainable development as the major challenge in the Rio Summit. World Summit on Sustainable Development was held in Johannesburg in 2002,

attended by 191 national governments, UN agencies, multilateral financial institutions and other major groups to assess progress since Rio. The Johannesburg Summit delivered three key outcomes: a political declaration, the Johannesburg Plan of Implementation, and a range of partnership initiatives. Key commitments included those on sustainable consumption and production, water and sanitation, and energy. Millennium Development Goals (MDGs) were the eight international development goals for the year 2015 that had been established in the Millennium Summit of the United Nations in 2000, following the adoption of the United Nations Millennium Declaration. Main goals were to eradicate poverty and hunger, universal primary education, gender equality and women empowerment, reduction in child mortality, improved maternal health, combating HIV/AIDS, malaria, and other diseases, to ensure environmental sustainability and to develop a global partnership for development. These were replaced by Sustainable development goals in 2015 and were enlisted in Agenda 2030.

1.9. Environmental Kuznets Curve

Environmental Degradation and Economic Growth International protection of environment and greater economic development are two legitimate concerns of the global community. What we are witnessing today is an era of trade openness, international economic linkages and unprecedented competition with countries pushing for further convergence. It has been believed and learnt from experience that a reduction in cross border trade and investment barriers can stimulate economic progress and foster greater welfare. But, the sustainability of such progression has been repeatedly questioned. The serious environmental damage caused in the process of growth acceleration leads one to believe that economic growth and quality environment are inherently conflicting. The EKC is one phenomenon, which counters this dichotomy between growth and environment as it offers greater economic growth as a means to solve environmental problems.

Understanding the theory of EKC

Inverted-U shape

According to the EKC hypothesis, environmental damage increases during the initial phases of economic growth, but diminishes once nations attain greater

altitudes of income, suggesting that the relationship characterizing income (economic development) and environmental damage takes the shape of an inverted U. This happens because countries at higher developmental levels have the necessary technologies for pollution abatement and also the necessary capital for implementing such technologies. The basic premise of the EKC theory is that, economic growth might bring about environmental damage initially, but in the end, the best and perhaps the only-way to achieve a better environment is by fostering further development. At lower levels of income, primary production dominates, natural resources are aplenty and generation of wastes is limited, but in the course of development and through industrialization, economies experience natural resource diminution and waste accumulation. During this phase, the relationship between environmental damage and economic development is positive. But with further economic growth, technological advancements, information efficiency and transition to services, the material bias of an economy becomes limited, which would bring about reduction in environmental damage. Figure 1.1. below present a hypothetical global EKC. The turning point in Figure 1.1. represents that level of income beyond which an economy could delink environmental damage from the process of economic development. This level of income is known as the threshold level.

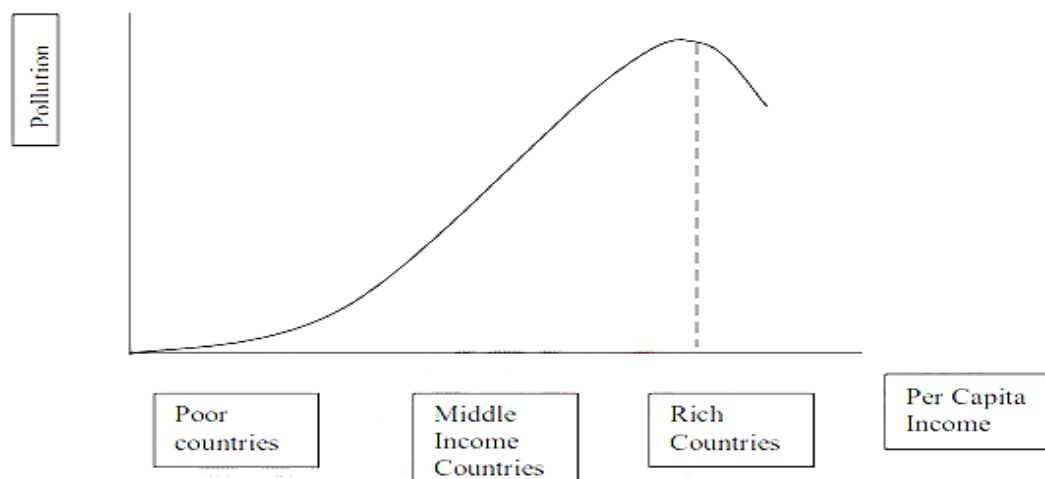


Fig.1.1. A Hypothetical EKC

Origin of EKC: The EKC is named after Nobel laureate Simon Kuznets who purported an inverted-U shaped relationship between economic growth and income inequality. Intrigued by the character of changes in the personal

distribution of income, Kuznets analyzed data for US, England and Germany and came to the general conclusion that the relative distribution of income as measured by annual income incidence in rather broad classes, was moving towards equality, particularly after World War I. He explained that a change in inequality was a consequence of the expansion of the high-income modern sector of the economy at the expense of low-income traditional sector. This transition from the traditional to the modern sector is expected to foster an inverted-U shaped association between income inequality and growth over time. In other words, as a nation undergoes industrialization and urbanization, opportunities for those with money increase while there is influx of cheap labor from rural areas to cities for better paying jobs. Under these conditions, the urban population would be characterized by an entire range from lower levels of income marked by these new entrants to the highest levels of income represented by the established high-income groups. This would result in the urban income inequalities being much larger than those for the agricultural population, which was organized in relatively small individual enterprises. But post the turbulent phases of industrialization, the dynamism of a growing and free economic society, would enable a rise in the income share of the lower income groups within the urban population. Inequality is then expected to decrease. It could be thus assumed that the inequality exemplifying the income structure would undergo a protracted thump: increasing in the early stages of economic development when the transition from pre-industrial to industrial civilization was most quick; become stabilized for a while; and then constricting in the later phases. Following the observation of Kuznets, the EKC hypothesis intends to represent a long-term relationship between economic growth and environmental degradation.

Check Your Progress:

Q.No	Short Questions	LOCF Mapping		
1.	List out the main objectives of Environmental Economics.	K1	CO1	PO1
2.	Explain the relationship between environment and economy.	K2	CO2	PO2
3.	Describe the concept of the material balance approach.	K2	CO2	PO2
4.	Explain the Malthusian perspective on environmental resources.	K2	CO3	PO3
5.	Identify the importance of environmental economics in policy making.	K2	CO1	PO4
Q.No	Essay Type Questions	LOCF Mapping		
1.	Discuss the scope and significance of Environmental Economics in modern economies.	K4	CO1	PO3
2.	Examine the material balance approach and its relevance to environmental management.	K4	CO2	PO3
3.	Evaluate the concept of sustainable development and its importance for future generations.	K5	CO4	PO4
4.	Critically analyze the environmental Kuznets curve and its implications for economic growth.	K5	CO5	PO3
5.	Apply environmental economics concepts to explain pollution and resource depletion problems.	K3	CO2	PO2

UNIT – II

ECONOMICS OF NATURAL RESOURCES

2.1. Introduction

Resources are seen as the basis for national prosperity, power and wealth. For example, the ability to harness energy resources in new ways is recognized as perhaps the major factor underlying the industrial revolution. Even more fundamental, food supplies depend on forests, fisheries, and agricultural land. Only in the last generation have agricultural land, forests, and fisheries been perceived and described as renewable resources. Of course, this does not imply unconditional renewal. Such resources are self-renewing at a limited rate, which may itself depend on the size of the stock in existence at any given time and on the extent and nature of human intervention into the stock dynamics. In contrast, minerals and many energy commodities now are seen as depletable or nonrenewable resources – resources for which only a limited, concentrated stock exists for allocation over all time. For these resources, a central issue involves when they should be extracted and used. Using a given portion of a stock at one time precludes the option of using that portion at another time. Even more recently have the environmental resources – air, water, open space – also been seen as renewable or, in some cases, depletable resources. The image of environmental resources, fisheries, and wild animal stocks as common property resources owned by everyone and hence by no one has played an enormous role in economic reasoning about these resources in recent decades.

2.2. Natural Resources

2.2.1. Definition

Natural Resources are ‘anything’ available in the nature, which are useful to the mankind, such as air, water, soil, mineral, forest, wildlife, etc. Natural Resources may be defined as any substance occurring in the nature, which is useful in its natural form. The value of Natural Resource depends upon the amount of the substance available and its requirement by the mankind. In other words, Natural Resources are useful raw materials available on the Earth. These occur in natural form, which are either used/consumed directly or modified in ways to make beneficial to the man-kind. For instance,

some substances are used as food, others as for different purposes or to meet vital needs and development of the life style. Thus, some resources are essential for the survival and others are required for the need and desire of the man-kind. A resource has also been defined as any part of the environment, such as land, water, air, mineral, forest, wildlife, etc., which the human beings utilise to promote their welfare, or it satisfies human needs. Further, any substance is considered a natural resource only when it is found in nature or extracted and purified, and is not created. For example, a pearl, when extracted from the bivalve shell is a Natural Resource; but when produced or created in the laboratory, it is not considered as a Natural Resource. Similarly, plants, trees, etc., found in forest are Natural Resources, but when plants are cultivated or produced from agriculture are not considered as the Natural Resources.

2.2.2. Classification of Natural Resources

Natural Resources can be categorized as:

1. Renewable, 2. Non-Renewable, and 3. Non-exhaustible.

1. Renewable: The renewable Natural Resources are those that are constantly available and/or can be replenished by themselves or by human efforts in a short period of time, such as trees, forests, animals, microorganisms, etc. In other words, renewable Natural Resources can be grown again or replaced within a person/generation lifespan, and thus, never run out. There are nutrients (made up of various mineral components /chemicals) in the soil which are required by the living beings. These move round and round in cycles and never run out. For example, when an animal eats a plant, it takes in nutrients from the plant. The nutrients are used in the animal's body, of which many nutrients may come out as waste, which goes in the soil. Likewise, when the animals die, its nutrients return back to the soil as well. These nutrients are then absorbed by the plants from the soil, and thus the cycle continues. So, nutrients are renewable Natural Resources. There are some renewable resources, which takes a long time to grow or replace. In that case, such renewable resources may be diminished and eventually be die out, if these are used up at a much faster rate than the time taken for their replacement or growth in nature. The rate of sustainable use

of a renewable resource is determined by the replacement rate and amount of standing stock of that particular resource. For example, forests, wild life, biomass, non-agricultural food, etc. Wild-life though considered as Renewable Resources, yet some of the endangered species can also be considered as Non-renewable, which are at the verge of being extinct. Similarly, forest is considered to be renewable resource, but in case trees are cut down to be used as bio-mass in the forest quickly or in selective area, it may disturb the ecosystem and gradually the forest will disappear. In that case forests are non-renewable source. Yet, there is another category of renewable resources, such as air and water that move in cycle from one place to another and often back. Another never ending renewable resource is Sunlight.

2. Non-Renewable: Natural Resources of this category exist in nature in a fixed amount and cannot be re-generated or replaced at the rate at which these are consumed or utilized, such as gold, lead, zinc, coal, oil, gas, etc. These are also known as Exhaustible Resources. Although minerals are discovered and exploited, but once these are used, these cannot be replaced or renewed. These are found both on Earth's surface as well as sub-surface, and are often difficult to find out. The quantity of such resources is fixed, and are considered as non-living things. For example, oil, coal and other minerals, which are supposed to be the most valuable natural resources, once used cannot be replaced, as such these may be exhausted the way these are being consumed. The non-renewable Natural Resources are not able to re-produce or renew in a considerable span of time. In fact, these take much longer period than the lifespan of a man or even generation, rather such resources take millions of years to form. In other words, the resources that cannot be replenished or reproduced in a short period of time (say within the life time of a human being or its generation). For example, fossil fuel minerals, viz., coal, oil, natural gas, etc., take millions of years to be formed. The present Oil Fields, which are being exploited for consumption, may go dry the way it is being consumed, which are in fixed supply. Soil is another example. Although fertility of the soil or the nutrient contents of the soil can be renewed with fertilizers, but top soil layer as a whole, if removed or eroded away, will take more than a lifetime of a human being to regenerate by natural process, as

such soil cannot be renewed within. The term renewable and non-renewable are time relative.

3. Non-Exhaustible: The resources that can last forever irrespective of human activities, such as air, water, and sunlight. These have natural re-generation and are in-exhaustible. Although these resources renew on its own continuously in the nature, these can, however, be deteriorated / degraded / polluted by the human activities/interference, which then becomes harmful also. Air and water, for example, move in cycle from one place to another, and often back where these started, again and again. Likewise, sunlight is also never ending. The Natural Resources may also be categorized as Inorganic and Organic. i) Inorganic : The resources, which are not alive, such as air, water, soil, mineral, etc. ii) Organic : The resources, which are alive, such as plants, animals, etc. Taking an example of clothing. Clothes are made up of natural fibre as well as synthetic material. The natural fibre includes cotton, silk, wool, or even animal skins. These all come from the Organic Natural Resources. On the other hand, synthetic fibres are made of polyester, acrylic, rayon, nylon, even plastic, etc. These come from inorganic minerals.

2.3. Types of Natural Resources

Natural Resources are inanimate and are a combination of three resources, which are available in the three realms of the Earth, i.e., Lithosphere, Hydrosphere and Atmosphere. Commonly, these are known as land, water and air. A thin contact zone of these three realms that has made life possible is termed as the Biosphere, which includes human, animal and plant resources. Therefore, natural resources can be categories as Land Resources, Bio Resources, Hydro Resources, and Atmospheric Resources. While the land-resources and hydro-resources in a particular geographical area are limited or fixed in quantity, the bio-resources keeps on varying with time under the interference of physical forces and human activities. A pervasive trend is observed in the bio-resources, where human population is increasing exponentially, at the same time population of other faunal and floral species is decreasing at an alarming rate.

2.3.1. Land Resources

Land is one of the most important natural resources. It covers about 30% of the total area of the Earth's surface. It includes rugged topography, mountains with steep slope, low-lying areas, desert areas, and thick forested areas. All of these areas are normally sparsely populated or uninhabited. On the other hand, there are plain areas and river valleys, which offer suitable land for agriculture, as such these are the densely populated areas. Land is used for different purposes such as agriculture, forestry, mining, building houses, roads and setting up of industries. This is commonly termed as Land use. Growing population and their ever-growing demand has led to a large-scale destruction of forest cover and arable land. Land degradation, landslides, soil erosion, desertification are other major threats to the environment, and on the other hand, agricultural land is being converted into rural areas and constructional activities. All these has created a fear of losing this Natural Resource.

1. Soil:

Soil has remained a source of living for human beings and animals. It also supports and nourishes plant kingdom, and thus, classified as the basic Natural Resource. Soil forms a part of the Earth's surface, and is formed by a long-term process of complex interaction of climate, topographic relief, flora, fauna, micro-organism, parent rocks and time.

The formation of soil can be visualized with the following formula :

$$S = (g.e.b) t$$

where 'S' is soil, 'g' is geology, 'e' is environment; 'b' is biological influences and 't' is time. It is estimated that the formation of one inch of soil takes nearly 500 to 1,000 years.

Soil is an important source for supply of vegetarian food. All vegetarian food in terms of vegetables and fruits comes from plants and trees, which get nourishment from various chemical elements in the soil, either through natural occurrence of minerals or in terms of natural fertilizers, such as potash, phosphate, nitrogen, sulphur, etc. In nature, soils restore its fertility by release of nutrients from decay of fallen leaves, twigs and dead bodies of animals; and also, biological fixation of nitrogen. Earthworms and rodents

further help to enrich the fertility by rotation of deeper soil to the surface by burrowing. Soil erosion and depletion are the major threats to soil as a resource. Factors that lead to soil degradation are deforestation, overgrazing, overuse of chemical fertilizers or pesticides, rain wash, landslides, floods, etc.

2. Minerals and Rocks:

There are many minerals on and in the Earth's crust. These can be categorized as Metallic Minerals, such as gold, silver, copper, iron, etc.; Non-Metallic Minerals, such as graphite, calcite, mica, quartz, feldspar, etc.; and Fuel Minerals, such as coal, oil, natural gas, etc. A few minerals, such as Uranium have been categorized as Metallic Fuel Minerals. Minerals are scattered all over the Earth, however, their concentrations are found at a very few places. Many minerals are still hidden and unknown as many inaccessible areas are yet to be surveyed. Mineral resources form the basis of industrial development and improvement of the life style of the mankind. Entire mankind largely depends on mineral resources in their day-to-day life. It is interesting to note that there are 33 minerals involved in a computer, and a simple bulb has many mineral components. Even plastics are made from petroleum jelly, which is a bi-product of the crude oil. Various minerals are involved in construction of buildings in one way or the other. Likewise, rocks also serve as building material, where marble, granite, quartzite, slate, etc., are utilized for making tiles and mosaic chips, which are in demand in modern urbanization. Thus, almost all the things that we use in our daily life have the involvement of minerals. The minerals and rocks fall under the category of non-renewable resources, as these are in fixed quantity.

3. Places of Nature's Scenic Beauty:

The nature's scenic beauty is one of the Natural Resources, which is being utilized in every country in form of tourism industry. It has found very useful, and more and more virgin areas are being developed to fetch sound economy. Mountains have always remained a source of curiosity and adventure for the mankind since the time immemorial, but it was never classified as a resource. But as people are suffering from the day-to-day mechanized life and heavy mental pressure of work load due to excess urbanization and industrialization, the people particularly from the urban areas now look

forward an opportunity to visit hilly regions from time to time for peace, tranquillity, entertainment. Even some visits the hilly region, particularly the Himalayan region for spirituality. Likewise, many people like to visit beaches, deserts, etc., which are nature's gift to the mankind. Such scenic beauty places have developed as a fast-growing natural resource-based activity in form of tourism.

2.3.2. Bio Resources:

Bio resources are those natural resources, which are consumed by the human beings for their need and pride.

1. Forests and Timber:

Forests were the main source of survival of the mankind in the ancient time, where the ancestors live in forest. Even today, there are many local tribal communities, who have the forests as one of the resources for their existence and subsistence. In addition, the forests harbour timber yielding trees, and non-timer forest products including medicinal plants and wild ornamental plants. Even the forests harbour wildlife, maintain ecological balance, controls wind force, provide humus to the soil, prevent soil erosion, etc. It plays a major role in enhancing the quality of the environment and also influence the local climate. Forests also offer panoramic or scenic view for recreation. Timber is a renewable resource, which is used for various purposes. Timber acts as a carbon store, where it plays an important role in reducing carbon emissions. Since most of the timber comes from forest, it requires long-term planning in producing timber in a sustainable way. Forests are natural habitat of flora and fauna and form the important natural resources, which are not only useful to the mankind for providing livelihood in terms of timber, wood, fodder, medicinal plants, etc., but also help to preserve biodiversity, maintain ecological balance, control climate and rainfall, and prevent soil erosion and controls floods. Forests also play a major role in enhancing the quality of environment by maintaining oxygen-carbon dioxide-nitrogen balance in nature. It provides humus to the soil and shelter to the wildlife. Above all, it offers panoramic or scenic beauty for recreation. Forests have also been designated as 'biodiversity hot spots'. Although Forest is considered to be renewable, by and large it falls under the category of non-

renewable resource, as already discussed above.

2. Non-Timber Products:

Non-Timber Forest Produces (NTFPs) are natural resources, which are extracted from the roots, stems, flowering panicles, fruits, leaves, etc. Based on the end products, the NTFPs of economic importance can be classified into the following categories:

- i) Bamboo, Cane and Grasses
- ii) Resin, Wax, Gum and Oleo-resin
- iii) Spices, edible plants, drug, etc.
- iv) Tan and dye
- v) Distillation and extraction products including grass oil
- vi) Oil seeds, etc.
- vii) Fibre and flosses
- viii) Miscellaneous products – Broom stick, Toko leaves, Jeng leaves, etc.

The NTFPs have a vast scope of commercial exploitation directly and indirectly, whereby these produces are processed to make value added end products. These are highly valuable as the easily available produces do not require high technology for value addition. Most important is that these do not invite environmental and ecological problems.

3. Medicinal Plants:

Plants have been used for medicinal purposes long before recorded history. Ancient Chinese and Egyptian papyrus writings describe medicinal uses for plants as early as 3,000 BC Medicinal plants have been used in traditional medical system, particularly the Ayurveda. According to the World Health Organization, nearly 80% of people worldwide rely on herbal medicines for some part of their primary health care. In the recent years, people are returning back to the herbal medicines particularly in view of the high cost of medicines and their side effects.

4. Wildlife:

Wildlife is an integral part of the ecosystem. Wildlife is a source of livelihood and subsistence. It provides useful products such as food, medicines, leather, bones, honey, lac, etc. Wildlife plays an essential role in the ecological and biological processes that are significant to life. It helps not only to preserve

biodiversity, but also maintains ecological balance of nature and natural cycle of food chain, which depends on endless interactions amongst plants, animals and micro-organisms. Wildlife falls under the renewable category; however, a large number of birds and animals are in the danger of getting extinct/on the verge of extinction. These are called endangered species. These species are facing major threat of extinction mainly due to hunting by greedy hunters for commercial purpose; pollution due to chemical and industrial waste; disturbance in migratory route and reckless cutting of forests to bring land under cultivation and inhabitation, which are affecting natural habitat of wildlife. There are many plant species also that fall under the category of the endangered species. Other than the endangered species, there are many species, which have been classified as vulnerable species and rare species. Vulnerable species are those, which have abundant population but their habitat is adversely affected, and may become endangered in near future. Rare species are those whose population is very thin because of their natural reproduction. Initiatives have been taken to preserve natural habitats of the wildlife. In this direction, 16 Tiger Reserves, 89 National Parks, 49 Wildlife sanctuaries and many Zoological Gardens have been set up in India. In addition, 14 Biosphere Reserves have also been set up in India, of which 4 have been included in the world network of Biosphere Reserves. These are i) Nilgiri at the tri-junction of Kerala, Karnataka and Tamil Nadu; ii) Nanda Devi in Uttaranchal; iii) Gulf of Mannar in Tamil Nadu; and iv) Sundarbans in West Bengal.

5. Micro-organisms : Micro-organisms are not seen by naked eyes, but are powerful renewable resource existing in the atmosphere, on the Earth (both land and sea), and even in animals and plants. A large number of micro-organisms fall in the groups of fungi, bacteria and viruses that by and large provide several benefits to the mankind in one way or the other. Some of the benefits include : natural fixation of nitrogen by symbiotic and non-symbiotic bacteria; maintaining ecological balance by saprophytic bacteria and fungi, which are responsible for decomposition of plants and animals into simpler products; some autotrophs micro-organisms produce food by photosynthesis process; etc. A large number of micro-organisms are known to have beneficial

characters like fermentation, curdling, which are commonly employed for the benefit of man. Even a large number of micro-organisms are also used to manufacture, on commercial scale, vaccines, medicines, vitamins, acids, proteins, hormones, etc.

2.3.3. Hydro Resources:

Water is a vital natural resource on the Earth and is a lifeline not only for the human beings but also all living beings. Fortunately, water is a renewable resource that remains in one form or the other. About $\frac{3}{4}$ of the Earth's surface is covered with water that harbours a large wealth of plant and animal life, both oceanic (marine) and aquatic (fresh water). It was in the primitive oceans that life originated almost 3.5 billion years back. Significance and importance of water in human life have been realized from the primitive stage of the mankind. Almost all the ancient civilizations were inhabited on the banks of a river or within a convenient distance from the sea. It was to ensure perennial supply of water for day-to-day activities. Apart from cooking and personal cleanliness, water was used for cultivation and irrigation of crops. In that early age, water was even a major mode of transport, which subsequently became an invaluable source of trade and commerce. Water as a natural resource is, thus, acknowledged as the basic need of all living creatures on the Earth. Snow is another natural resource that forms a part of the water resource. With the increase of population and expansion in industry the demand of water has increased over the years that has led to the water scarcity. The problem of water shortage has further been aggravated with the overexploitation and pollution or contamination of water. The overexploitation has led to the decrease of ground water level. On the other hand, quality of water has also affected severely due to contamination of surface water, such as arsenic, fluoride, nitrate, iron, etc.

1. Surface Water:

As mentioned earlier, although there is enough surface water, but fresh water amounts to 2.7% only. This vast resource is primarily utilized for drinking and irrigation purposes. It is being effectively converted into hydropower resource. Another dimension of the surface water resource is the development of Inland Water Transport System, which is a viable mode of cheap

transportation.

2. Ground Water:

It is the water that seeps/percolates through rocks and soil and is stored below the surface of the Earth. The places where ground water is stored are called aquifers. Ground water is the main source of drinking water as well as agriculture and industrial use. It is an integral part of the hydrological cycle and thus, largely depends on the rainfall and precipitation. Less than 2 % of the Earth's water is ground water.

2.3.4. Atmospheric Resources:

Earth is blessed with Atmospheric Resources that provide the basis of life on the Earth, and at the same time it protects the human being from harsh sun rays. Atmosphere above the Earth provides and replenish carbon dioxide, oxygen and nitrogen that makes existence of the living beings. It also generates hydrological cycle on the Earth. In addition, there is an ozone layer present in the atmosphere. It is in form of a gas composed of three atoms of oxygen (O₃). Ozone occurs both in the Earth's upper atmosphere and at ground level. Ozone present in the upper atmosphere is called "Stratospheric Ozone". This layer is of utmost importance as it filters out all the ultra violet rays of the sunlight. In case of non-existence of the ozone layer, direct sunlight on the Earth may cause many hazardous consequences on human health and plant and animal life. Ozone present at the ground level is called 'Tropospheric Ozone'. It is considered harmful as it is created by chemical reactions between oxides of nitrogen (NO_x) and volatile organic compounds (VOC). It happens when such pollutants, emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other sources, chemically react in the presence of sunlight. Breathing in such ozone layer can trigger a variety of health problems, particularly for children, elderly, and people of all ages who have lung diseases such as asthma. Ground level ozone can also have harmful effects on sensitive vegetation and ecosystems.

The atmospheric resources include Air, Rain, Sunlight, and Heat (Atmospheric Temperature).

1. Air:

Air is an important and vital natural resource essential for any living being.

Oxygen and Carbon-dioxide, the two main components present in the air, are the fundamental elements of breathing. Presence of Oxygen and Carbon-dioxide in the air vary in space and time, but the variability of Oxygen is much smaller than that of Carbon-dioxide. Air is not uniform throughout the atmosphere, and its density reduces gradually with the altitude. The composition of air also varies different layers of atmosphere. It has 78% nitrogen, 21% oxygen, and 0.03% carbon di-oxide at the surface of the Earth. Oxygen is directly responsible for life on the Earth.

2. Rain:

Rain, also known as 'precipitation', forms a part of the atmospheric weather cycle, and is responsible for varying eco-systems on the Earth. Rain provides water to drink as well as to recharge the sub-surface water table, also known as ground water. It helps to grow vegetation and agricultural crop. Farmers consider Rain as the nature's gift that facilitate them to harvest crops. They particular look for this gift during drought conditions.

3. Acid Rain:

Acid Rain is a broad term that includes any form of precipitation with acidic elements that fall to the ground from the atmosphere. In other words, Acid Rain is produced when acidic chemicals are amalgamated into rain, snow, fog, or mist. The "acid" in acid rain comes from sulphur oxides (SO_2) and nitrogen oxides (NO_x), which are emitted into the atmosphere by vehicles, oil refineries, industries, etc. These gases when react with rain water forms sulphuric and nitric acids, hence such rain is called Acid Rain.

4. Sunlight:

It is also a renewable natural resource that provides light, heat and energy. It is the prominent source of natural light for the human being on the Earth. Sunlight is also a potential source of Vitamin 'D', particularly 'D₃'. Sunlight is of utmost importance and the integral part of the plant's life, where plants particularly the leaves absorb sunlight for the photosynthesis process that produces energy for the growth of plants. Sunlight is being used as the Solar Energy also.

5. Atmospheric Temperature (Heat):

The atmospheric temperature acts as a resource, as it stimulates to produce

many natural resources, such as plants, animals and micro-organisms. It also provides enough heat to regulate the environment around the human beings. Atmospheric temperature also governs soil fertility, hydrological cycle and many other abiotic and biotic parameters of the Earth.

2.4. Conservation and Sustainable Use of Natural Resources

Natural Resources, which are utilized directly and indirectly in the day-to-day life, are essential for the livelihood of the human society. Initially, the mankind has used Natural Resources to fulfil his basic needs. Subsequently, with the advancement in Science & Technology, it started manipulating the resources for their higher orders of need and greed, and even gone beyond tolerance limits of the nature, thereby, affecting the environment and ecology adversely. In fact, Natural Resources, such as microorganisms, animals and plants together with climate and water conditions, are inherently complex, dynamic and inter-related. All these interact to form a multifaceted web of ecosystem upon which all life depends, hence any change in one of these have long term impact on ecosystem. Stressing amongst various factors that determine the quality of our environment, KD Singh (2002) opined that most fundamental is the way we make use of our Natural Resources. Need is to identify priorities of resource utilisation to achieve the goals of sustainable socio-economic development. Natural Resources are considered to the Nation/State's asset that earn economy, which may be in form of minerals, oil & natural gas, forests, tourism, etc. Goods produced from Natural Resources form the basis of economy in many developing countries. Even the local trade by and large is based on the niche resources. However, it is human attitude towards the resource management that makes the nation developed, rather than the availability of resources. For example, Japan is poor in Natural Resource base, but is the only nation in Asia having the status of developed country. On the other hand, African countries are full of natural resources, yet those are economically poor. America is another example, who always look forward to have the best talent of the world to develop its own natural resources. As a result, America is the number one economic developed country in the world. In India, taking the example of the State of Arunachal Pradesh, Trilochan Singh (2002) has shown that in spite of being resource-

rich and having comparatively low population, the State has been a victim of backwardness, because of :

- i) most of the untapped minerals lie in the forest land, and the Forest Conservation Act, 1980 prohibits use of forest land for non-forestry purpose;
- ii) the State lacks infra-structural facilities to tap hydroelectric power potential;
- iii) mineral based projects are not economical viable because of high transport cost;
- iv) lack of infrastructure development in terms of roads, and lack of proper communication in terms of poor networking;
- v) lack of resource management in terms of information technology; and
- vi) lack of industrial activity and commercialization in terms of horticultural products, handicrafts, small scale cottage industry, etc.

Basic problem is that the increasing needs and traditional practices of sharing resources have put the people at the cross roads of traditions and transition in various fields of life. According to the Organisation for Economic Co-operation and Development (OECD, 2009) poor people's livelihoods remain heavily dependent on Natural Resources. OECD identified seven natural resource sectors, which have a critical role to play in sustaining pro-poor growth. These are : fishery; forest; wildlife and nature-based tourism; soil productivity; water security; minerals; and renewable energy. These key resources with improved management can contribute to sustainable pro-poor growth, thereby, reducing poverty. One of the fastest growing segments is the nature-based tourism that holds high potential, which may even provide employment and income generation opportunities. Whereas exploitation of Natural Resources is a key factor in economic growth and development, yet these have a serious impact on environmental and natural hazards. Vice-versa, natural hazards disrupt Natural Resources to a greater extent. As already mentioned above, most of the Natural Resources are limited, hence over exploitation of such resources may not only deplete the non-renewable ones, but also causes adverse effect, such as deforestation,

desertification, extinction of species, forced migration, soil erosion, increase of greenhouse gas, water pollution, forest fire, landslide, etc. Theoretically, impacts of natural disasters on Natural Resources and environment can be direct or indirect as well as positive or negative (Israel and Briones, 2013). On the positive side, floods improve soil fertility as they deliver nutrients from uplands to lowlands; and temporarily create a water habitat for fishes and other aquatic animals. In addition, typhoons and floods increase moisture contents in air, and also dilute/clear air pollution. The negative impact, on the other hand, includes soil erosion, siltation and sedimentation, waste accumulation, water pollution, deformation of land topography, etc. Further, drought results into the low soil fertility and increase in saltwater intrusion. Natural Resources are under threat from different aspects, however, following two are prominent:

i) Population Pressure: Ever increasing population is the most significant threat to Natural Resources. On one hand, consumption of Natural Resources has considerably increased, and on the other hand, a large part of agriculture land and/or forest land is being curtailed by utilizing for human settlement and respective infra-structure facilities.

ii) Environmental Pollution: Modernization in the life style of man-kind has contributed significantly in deteriorating the environment, which has serious repercussions on the habitat of Natural Resources. It is often observed that certain resources are over exploited, and many others are not been able to utilize or under-utilized. For example, forest resources are over utilized leading to environmental and ecological problems, whereas a variety of other resources, particularly mineral and water resources are either under-utilized or still in dormant stage in some States. However, exploitation must be done within the tolerable limits. In this context example of over exploitation of limestone in Mussoorie hills is cited, which resulted into depletion of forest cover and water sources, increased landslide, and caused drastic change in the climatic conditions. The resources given by the nature required to be utilized wisely in accordance with the conspicuous balance between present and future needs. These include destruction and degradation of well grown forests, depletion and pollution of water sources, despoliation of land, etc.

Simultaneously, mechanism be developed to exploit Natural Resources through scientific and technological interventions in such a way that it does not affect the ecological balance. It is possible through transfer of scientific knowledge about conservation of such resources, particularly non-renewable resources, at grass root level with people participation. The thumb rule for conservation may be Reduce, Recycle and Reuse of Natural Resources.

(i). Reduce - use limited and avoid wastage of Natural Resources. For example, turn off the lights when not in a room. It will reduce fossil fuel used to make electricity. Ride on bicycle and walk more, to reduce the amount of fuel used in vehicles.

(ii). Recycle - certain resources, which may be recycled for use in another form, may be promoted. For example, paper, plastic, glass, metals, etc., can be used again through recycling.

(iii). Reuse - certain items may be used directly again and again. For example, plastic or glass jars can be used for storing things in the kitchen.

2.5. Conclusion

The pace of development and processes of economic growth of any region depend upon the extent and intensity of the utilization of niche Natural Resources, which are the heart-line of the region. However, Natural Resources are diminishing rapidly not only due to the increasing pressure of growing population but also by their ruthless exploitation with the passage of time. Since these are distributed unevenly, it necessitates a detailed and comprehensive inventory of available resources, their evaluation, and planning, so as to conserve them for future generation. Every human being should realize the importance of conserving Natural Resources and adopt suitable mitigation measures to preserve these. It may be possible through creating public awareness about the importance, need and sustainable use of natural resources in their native language avoiding complex scientific terms.

Check Your Progress:

Q.No	Short Questions	LOCF Mapping		
1.	Define natural resources and explain their importance in economic development.	K2	CO1	PO1
2.	Explain the concept of exhaustible resources with examples.	K2	CO3	PO3
3.	Distinguish between renewable and nonrenewable resources.	K2	CO3	PO3
4.	List out the major causes of depletion of natural resources.	K1	CO2	PO2
5.	Identify the economic importance of renewable resources in sustainable development.	K2	CO4	PO4
Q.No	Essay Type Questions	LOCF Mapping		
1.	Discuss the classification of natural resources and their role in economic development.	K4	CO1	PO3
2.	Examine the economic principles governing exhaustible resources.	K4	CO3	PO3
3.	Evaluate the impact of resource scarcity on economic growth and development.	K5	CO2	PO4
4.	Assess the effectiveness of policies for conservation of natural resources.	K5	CO4	PO4
5.	Design an economic framework for efficient utilization of natural resources.	K6	CO5	PO5

UNIT – III

MARKET FAILURE

3.1. Introduction

Economists have considered environmental degradation as a market failure. Because of market failure imposes external costs on the society. This means that externalities like pollution disrupt the smooth functioning of the market system. The external costs imposed on the society not accounted for by the firms, are not reflected in relative market prices. There are three important functions performed by the environment that are relevant for an examination concept of pollution as an externality. They are: (i). The environment acts as a supplier of natural goods such as beautiful landscape. (ii). It acts as supplier of natural resources which are used to create economic goods and (iii). The environment acts as a sink into which the inevitable by products of production and consumption activities can be discarded. It is otherwise called the waste assimilative function of the environment. Apart from the above said three important functions of the environment, environment acts as a life sustaining system. Thus, on the above lapsed function of the environment one can analyses the externality implications of pollution that leads to market failure.

3.2. Market Failure

Market failure refers to the divergence between the market price of resources and those prices that would have to exist if these are marketed optimistically. Similarly, environment functions as a waste assimilator also have no market. If the four environmental functions were priced then their use would have been different from what it is at present. This treatment of environment services and functions as free goods, results in market failure.

Externality

Every country has limited resources to fulfill unlimited wants of its populace. Though it is not possible to fulfill all the wants of everyone but the efficiency in production and allocation can help to maximize the fulfillment of wants for present and future generations. Sometimes markets may fail to produce and allocate goods among consumers, in most efficient way. This inefficiency in production or allocation is known as market failure. Before a detail discussion

on market failure and environmental economics let's imagine a lonely island where only a single human being 'A' is living. There is a small pond, the only source of water on the island. 'A' is depending on milk cattle for his livelihood as he knows no other work. There is no conflict of interest with anyone in decision making as he is alone. Now another person 'B' came to this island. 'B' wants to grow vegetables for his livelihood. For growing vegetables and raising animals, pond is the only source of water. Now there may or may not be a conflict of interest between A and B depending on the quantity of water in the pond. If water is sufficient for both of them there will not be any rivalry between them because the consumption of one is not going to affect the consumption of another one. We may say that here pond water is non rival good. Now third person 'C' comes to the island. C wants to use the pond water for making fruit juice for his livelihood. But the pond is not big enough to provide sufficient water for all of them. Now there is conflict of interest among all of them as the congestion has started. Assuming that there does not exist any rule regarding the use of pond water so that anyone can use it or we may say that pond water is an open access good. Similar is the situation with most of the open access goods around us like unrestricted highways, fishes in the sea, forests etc. Because of increasing population, the burden on natural resources is increasing and most of these resources are overburdened. We may say that the congestion has started everywhere and in absence of well-defined property rights the congestion leads to overuse of the resource and hence the market failure. Coming back to our example, suppose that A's animals start bathing in pond making water dirty for fruit juice. In the absence of property rights C has no option but to put a water filter system. A has created a negative externality for C as he has to bear the cost of water filter system.

There are so many examples of environmental externality around us. Hunting of endangered species, air pollution by airplanes or vehicles on the road, toxic waste disposed off on land, drainage of untreated polluted water into the river or ground water are among the few examples where ecosystem, air, land or water is affected because of negative externality. In all these cases MPC is much lower as compared to MSC. In these examples not only, the present

generations have to bear the cost of externality but also the future generations will have to bear it. It is quite possible that MEC is much higher than our expectations. Assume that the private market for textile manufacturing is perfectly competitive. Textile manufacturing requires large amount of water for its production process. Further assume that these manufacturing units are disposing off its waste water, without treating, into the ground water. The supply and demand curves for the industry are denoted by following linear equations:

$$\text{Supply } P = a + bQ \dots\dots$$

$$\text{Demand } P = c - dQ \dots\dots$$

Here the supply curve also represents the marginal private cost as the presence of externality makes private cost different from social cost. The demand curve also represents marginal private benefit. We also assume that the agency supplying the water to the city is using this ground water for water supply. The externality will increase the cost of water treatment hence this is production externality. The production externality affects the supply curve which is also MPC and the consumption externality affects the demand curve which is also marginal private benefit curve (MPB). The equation 7 and 8 may be written as:

$$\text{MPC} = a + bQ \dots\dots$$

$$\text{MPB} = c - dQ \dots\dots$$

COMPETITIVE EQUILIBRIUM

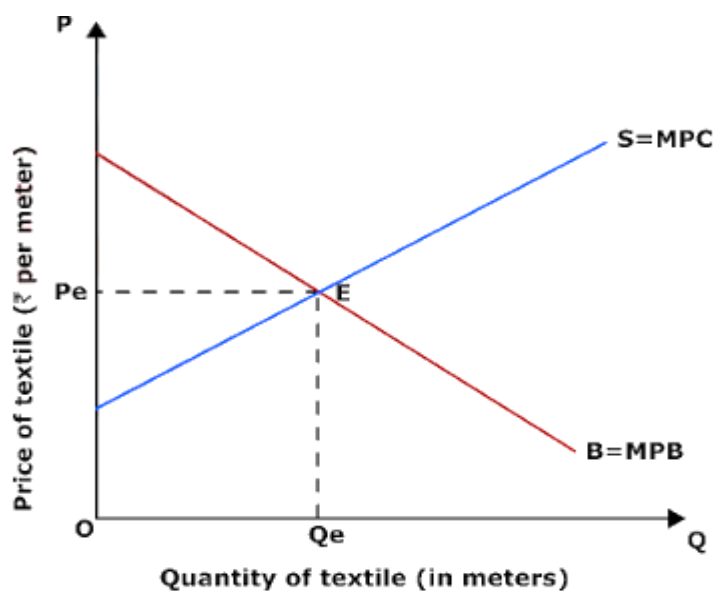


Fig.3.2.

Point E represents competitive equilibrium where the curve MPC intersects MPB. This equilibrium is not including the marginal external cost. Fig.3.2 is showing the competitive equilibrium of textile manufacturing. Point E represents equilibrium quantity and price. Here the market fails as this equilibrium is ignoring the externality. Though it is quite difficult to estimate the cost of externality, but there are many methods in economics to determine the approximate cost. Suppose the marginal external cost (MEC) is increasing function of quantity of textile:

$$MEC = eQ \dots\dots$$

we can find the equation for MSC:

$$MSC = MPC + MEC = a + bQ + eQ = a + [b+e] Q \dots\dots$$

We can find the efficient equilibrium if we consider the point of intersection of MPB and MSC instead of MPC to find the equilibrium. The externality at this point E_1 has become irrelevant. We can easily find the welfare gain to the society. From the perspective of the firm, there is loss in the profit equal the area of triangle EE_1A . From the perspective of the society as a whole, there is a gain equal to the area of rectangle EAE_1B . The net gain is the welfare gain to the society minus profit loss to textile manufacture and that is represented by the area of triangle EE_1B .

MARGINAL SOCIAL COST

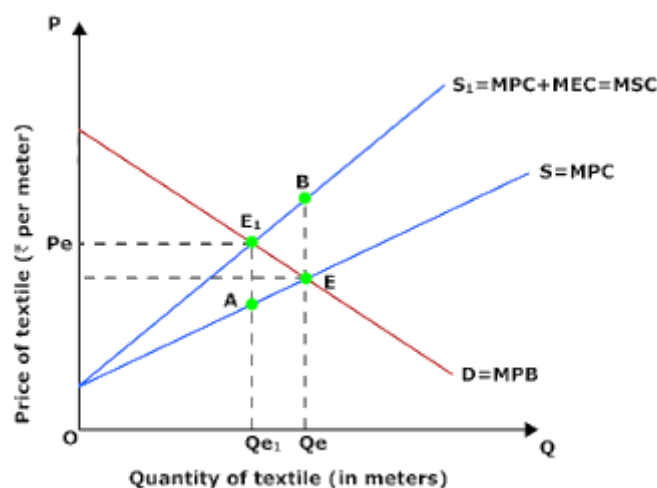


Fig.3.3.

At point E_1 efficiency is restored. The externality at point E was Pareto relevant but it became Pareto irrelevant when the equilibrium is determined by MSC curve instead of curve MPC. But in case of environmental externality property rights are undefined. Our environment is like an open access public good

where the property rights are not defined either in favour of polluter who may be compensated to reduce pollution or in favour of victim. As in figure there was overproduction of textile by not considering marginal external cost, similarly in the absence of well-defined property rights we are overproducing the market goods. This overproduction with negative externality is damaging the environment and all of us have to bear this marginal external cost and loss of welfare.

3.3. Tragedy of Commons

The tragedy of commons was a theory put forth by Garrett Hardin(1968). This theory especially talks about the misuse of public property and its affect on the environment and humans. Garrett explained this theory with the help of his famous shepherd example. In it he states that, every shepherd is entitled to a pasture of land where he can allow his sheep to graze, but when he starts encroaching into another shepherds pasture it has several effects. Firstly, the land since it is over grazed get denuded and secondly for want of food the sheep begin to die or can affect the output. Hardin story is of a pasture used in an uncoordinated way by community of shepherds, but its logic applies as well to a fishery and competing fishers, to oil fields for uncoordinated drillers of oil, to rivers that receive polluted waters and a group of separately operated waste dischargers.

Right from olden days, the natural resources like air, water, etc, have been owned publicly and it is impossible to claim private ownership. We find that the resources are over exploited and misused as the individuals are provided with little cost or no cost. These individuals who exploit the resources reap full benefit but bear only the fraction of the damage cost of his pollution. Thus, if there is absence of legal operations, every individual will ignore the drastic effects of his pollution on the environmental quality of the atmosphere. This will lead to a deterioration of the air quality and the society may end up worse off. until and unless individuals maximize their self-interest, the cost of externality would not increase from the level of optimality. Unfortunately, this kind of perverse social situation is continued which has come to be known as the “tragedy of Commons”.

The “tragedy of commons” is true not only to one individual country, but also at the international level. The phenomenon of endangered species is the result of international competition in exploiting oceans resources. The concern of this endangered species has made the nations to limit their operations within 200 miles limit. The commonly owned other community resources present another type of environment problems. For example, we can see heaps of garbage in the middle of the road; effluents into the atmosphere lead by the factories; and the beaches, parks and pedestrian walking paths used as toilets by the people. This is due to the lack of enforceable property rights to commonly used resources. John Galbraith calls this as “public squalor amid private affluence”.

3.4. Pigouvian Fee

In 1920 the economist Arthur C Pigou favoured the imposition of tax as a corrective measure to check the pollution, known as pigouvian tax or Pigouvian fee. This tax is to be imposed on the producers of pollution and is to be set equal to marginal damage. The imposition of tax is a corrective measure to deal the market failure due to negative externality. It helps in restoring the Pareto Optimality by imposing tax on pollution.

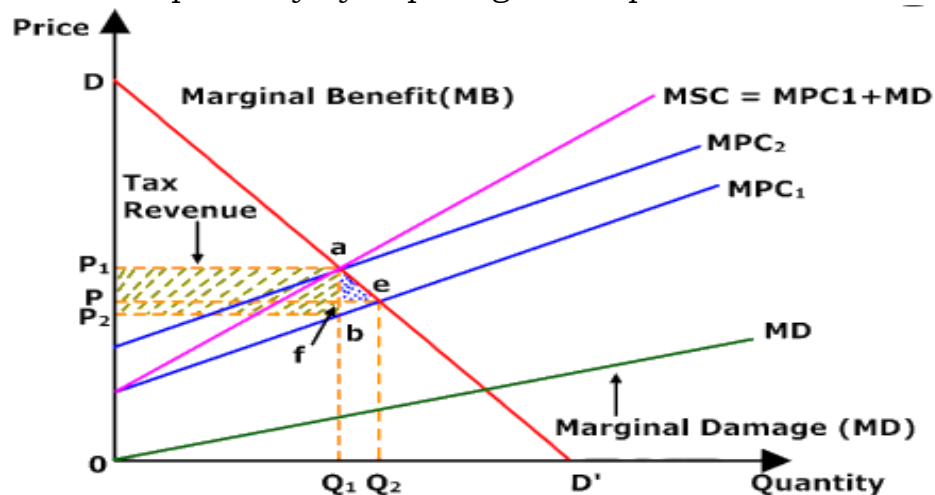


Fig.3.4.

MPC_1 = Marginal Private Cost without Tax

MPC_2 = Marginal Private Cost after Tax

Q_2 = Quantity before Tax

Q_1 = Quantity after Tax

$P_1P_2 = \text{Tax Rate}$

$P_1abP_2 = \text{Tax Revenue}$

The firm emitting pollution does not include the damage to the society due to pollution which is a negative externality, in its private cost. The point where marginal private cost (MPC_1) of the firm (also the supply curve of the firm) intersects the marginal benefit curve (MB) (also the demand curve) is efficient point from the firm's point of view but not from the society's point of view. This is because the marginal cost for the society is greater than the marginal private cost of the firm. If a factory disposes its chemical waste in the river without treating it and this river is the source of water for the people living in nearby town. Then the people living in this town will have to bear extra cost for treating this water. Pigou /argued for the imposition of tax on this factory based on its marginal damage.

MD is the marginal damage curve which increases with every unit increase in production. When MC_1 is combined with the marginal damage (MD) it becomes MSC which is Marginal Social Cost. You would notice that the slope of MSC is greater than MC_1 , since it is $MC_1 + MD$ which produce MSC. When the Tax was not being imposed the output was unduly being encouraged, that is, OQ_2 . But with the introduction of tax the production comes down to OQ_1 , which is the optimal level of production from the society's point of view because the Marginal Benefit (MB) is equal to the (MSC) the marginal social cost. The state gains in terms of Tax revenue to the time of $PabP_2$. When there was no tax consumers were paying OP. The consumers were enjoying the consumer surplus at the cost of the society equal to a net value of 'afe' because MSC was higher than the MB. This was due to over production of a polluting product equal to Q_1Q_2 . After the tax is imposed, this gets eliminated and the society benefits. When a tax equal to marginal damage will be levied on the firm the firm's marginal private cost will increase by the amount of tax as this tax is equal to marginal damage the new marginal private cost inclusive of tax becomes equal to the marginal social cost. The new equilibrium point, the point of intersection of marginal benefit and the marginal private cost (MPC_2) inclusive of pigouvian tax is socially efficient point and represents efficient level of output and the price. Neither the burden of tax will reduce the

production of the firm below the efficient level nor the production of pollution nor is the emission by the firm more than the optimum level. The efficient tax equal to marginal damage for the victims and the marginal saving for the firm helps to restore the Pareto optimum level of output from market failure. The shaded area shows the total tax paid by the producer which increases the marginal cost for the producer. The vertical distance of shaded area is per unit tax. This per unit tax is exactly equal to marginal damage and marginal saving at the point of their intersection.

3.5. Property Rights

Property rights are a set of guidelines, norms or regulations or rules or entitlements. Because of these entitlements, the owners will have some privileges and obligations as well, so far, the use of resources or use of assets are concerned. Here, we are emphasizing two aspects, viz. i) property rights are the entitlements because of these entitlements, we will be able to define the ownerships privileges as well as obligations for the use of resources or use of the assets is concerned; ii) moreover, we can have exclusive authority to determine how resources is used and whether the resource is owned by the government body or by some private individuals or groups. Property right or exclusive authority is one of the fundamental attributes of an economic good. While defining economic goods, also we are using the very features of property right.

3.5.1. Types Of Property Rights

There are three types of property rights are followed as:

1. Public property rights; 2. private property rights; 3. Common property rights.

First one is public property right. Here the ownership right is held by the public. If the resource or a particular asset is owned by the government itself or public authority, then its use has to operate under a set of determined rules.

Second is, private property right. So, here the right to use the property or resources is given to the private individuals itself. So, individuals do have the ownership and exclusive right to the services of the resources and they can

get all the benefits out of the use of their resources. Let us say the benefits that a private property owner can get from building. Because of the exclusive property right, the owners do have right to rent and get the benefits or can use for their own accommodations and can also sell or donate as a gift to somebody. If ownership or property right is held by the private body, they can get the services out of the particular resource or particular assets.

Third category of property right is the common or collective property right. What is the common or collective property right?

So, in the first case, public property right, the resources are owned by the government itself. And, the government determines the rules- how to use and what kind of uses and similarly, in case of private property right, the right or ownership is held by the private body itself, private individuals or private groups. But in case of the common property or collective property rights, the property right is held by group of individuals or groups in common. And by getting collective property right, the particular asset or resource is jointly owned; access use and exclusion are controlled by joint decisions only.

So, now, after understanding the very definition of the property right, let us talk about the characteristics of the property right.

3.5.2. Characteristics of Property Rights

The first characteristics that we need to state is the characteristics of exclusivity. The property of exclusivity states that all the benefits and called costs over the resources or assets can be accrued to the owner and to the owner only, no one else, if the owner has the property right.

And, the second characteristics of property right is transferability. It means, if you have the property right, then you do have the freedom to transfer the ownership right on this particular property in discussions. The holder of the resource who enjoys the property right can also enjoy the privilege of transferring property.

Another characteristic of property right is enforceability. It means if someone has the property right on a particular resource or asset, then others cannot encroach on that particular property. Thus, it gives a kind of security over the resources or assets. So, in case of enforceability, property right should be secured for involuntary seizure and encroachment.

And, the last characteristics of this property right is comprehensibility. It means the presence of well-defined ownership. Whether it is owned by the private persons, or public authority or a government, collectively by group of persons or group of individuals having right users right or property right on these particular resources or the asset in questions. So, this is how these characteristics help us defining the economic good.

So, now let us discuss about what is the optimal externalities. Now, we will be having another concept on externality before understanding the Coase theorem.

Optimal Externalities:

The optimal externality can be understood by the help of marginal net private benefit and marginal external cost. When the firm is producing, pollution is treated as an externality which is a byproduct of the output that the firm is producing. When the firm is a polluter, the firm will be incurring costs, when it undertakes or produces the output and as a result it will also be producing the pollution or externalities. The firm incurs costs for undertaking productions. The firm also sells its output and gets the revenue. So, now, the firm is getting the costs in terms of cost of production, and also is receiving benefits in terms of revenue after selling the products. And, we also know that when the firm is producing its products, it is also giving rise to a kind of externality which is known as the pollution. But pollution cost is not included in its cost of production.

We can find net private benefit by drawing a difference between total revenue and total cost. Total revenue is the amount that the firm gets after selling its products and the total is only the cost of productions not pollution cost. So, difference between total revenue and total cost is known as the net private benefit. When pollution cost or externality cost is added with total private cost, it is known as the social cost. But here we are only concerned about the private benefits and private costs that is why, we have not taken into account pollution because pollution is an external cost or social cost.

3.6. Coase Theorem

Generally, when there are some externalities, Government must interfere through different mechanisms or instruments like taxes or

subsidies. But even the Government is not interfering and we can also move towards the social optimum and we can internalize the externalities. So, that is the very gist of the Coase Theorem. Now, let us discuss this Coase Theorem in detail.

So, as you understand that there is a challenge to achieve the optimal level of externalities. And, Coase tried to show that how this optimal externality can be achieved without the intervention of the Government. So, he delineated his thoughts in the problem of social costs, which was published in 1960. And, because of which he got his Nobel Prize in Economic Sciences. And, when the Nobel Committee cited that two most important articles by Coase Ronald Coase, were 'on the nature of the firm', which was published in 1937; along with the 'Problem of Social cost', which has published in 1960.

So, basically the second one the problem of social costs, it talks about if there are no transaction costs, then the private parties can bargain and negotiate to internalize the externalities, without even the intervention of the government. If, there is no transaction costs and there are the bargaining and negotiations among or between the private parties, that can lead to the social optimal externalities. He bagged this Nobel Prize in Economic Sciences in 1991 for this contribution.

Assumptions

Assume a world in which some producers and consumers subjected to externalities generated by other producers and consumers. Further assume,

1. Everyone has perfect information
2. Consumers and producers are price takers.
3. There is cost less court system for enforcing agreements.
4. Consumers maximize utility and producers maximize profit.
5. There are no incomes or wealth or effects.
6. No transaction costs.

In this case the initial assignment of property rights regulating externalities does not matter for efficiency. If any of these conditions does not hold well the initial assignment of rights does matter. Thus, in Coase Theorem, the optimal environmental allocation is independent of the distribution of property rights. The wider implication is that by defining private property rights, conditions

by which decentralized bargaining may know more about the relative values involved – abatement costs and damages – than anybody else, so there is some hope that the true efficiency point will be arrived at. Also, because it would be a decentralized system there would be no need for a central bureaucratic organization making decisions that are based mostly on political considerations instead of the true economic values involved. Ideas like this have led some people to recommend widespread conversion of natural and environmental resources to private ownership as a means of achieving their efficient use.

Conditions:

In practice of course, for a property rights approach to work right certain pre requisites need be fulfilled, essentially four mains,

(i). property rights must be well defined, enforceable and transferable.

(ii). Transactions cost should be at a minimum.

(iii). There must be a reasonably efficient and competitive system for interested parties to come together and negotiate about how these environmental property rights will be used.

(iv). There must be a complete set of markets so those private owners may capture all social values associated with the use an environmental asset.

If firm A cannot keep firm B from doing whatever the latter wishes, of course a property rights approach will not work. In other words, owners must be physically and legally able to stop others from encroaching on their property. Owners must be able to sell their property to any would be buyer. This is especially important in environmental assets. If owners cannot sell their property, it will weaken their incentives to preserve its long run productivity. This is because any use that does draw down its long run environmental productivity cannot be punished through the reduced market value of the assets. Many economists have argued that this is a particularly strong problem in developing countries; because ownership rights in these settings are often ‘accentuated’ and people do not have strong incentives to see that long run productivity is maintained.

Check Your Progress:

Q.No	Short Questions	LOCF Mapping		
1.	Define market failure and explain its causes.	K2	CO1	PO1
2.	Discuss the concept of environment as a public good.	K2	CO1	PO1
3.	List out the characteristics of public goods give examples.	K1	CO1	PO1
4.	Identify the economic consequences of market failure in environmental resources.	K2	CO2	PO2
5.	Explain the role of property rights in managing environmental resources.	K5	CO2	PO4
Q.No	Essay Type Questions	LOCF Mapping		
1.	Discuss the concept of market failure and its implications for environmental resources.	K4	CO1	PO3
2.	Analyze the tragedy of commons and its impact on natural resource management.	K4	CO2	PO3
3.	Evaluate the effectiveness of Pigouvian fees in controlling environmental pollution.	K5	CO4	PO4
4.	Identify the role of property rights in reducing environmental externalities.	K5	CO4	PO4
5.	Assess government policies aimed to correcting market failures in environmental resources.	K5	CO4	PO4

UNIT - IV

VALUATION OF ENVIRONMENT

4.1. Introduction

The environmental problems the developing countries face are considerably different from those occurring in industrialised economies. For example, many rural populations in the developing economies depend on the direct exploitation of natural resources for agriculture, livestock rearing, fishing, basic materials and fuel, both to meet their subsistence requirements and to sell in markets for cash income. Rapid land-use change has meant that many natural environments and habitats are disappearing quickly with the result that critical ecological resources and functions are being disrupted or lost. The environment in developing countries is, therefore, very much related to health and welfare of rural and urban households. And, the basic production and consumption decisions of these households have a considerable impact on natural resources and environmental services. The lack of basic water supply, sanitation and other infrastructure services suggests that households highly value increased public provision of resource-based services. As a result, there has been a significant growth in the application of Household Production Function (HPF) and Production Function (PF) approaches for valuing non-market environmental goods and services in developing countries. They have now recognised the importance of the environment to human welfare and economic livelihoods.

Various types of environmental goods their classification on the basis of their use value and non-use value. Environmental resources provide number of benefits that allow human beings to live and enjoy the earth. The services provided by environmental goods are highly valuable therefore economists are concerned about assessing the value of such goods A vast majority of environmental goods are not traded in markets, majority of these goods are public goods This model basically deals with knowing the environmental resources their classification and valuation concept Environmental values are often categorized as use values and non-use values Use values refer to current direct and indirect ways in which people make physical use of an environment good, while indirect use benefits from environmental goods are associated

many services that are provided like forests provide carbon storage, biodiversity conservation etc., these in turn provide number of indirect benefits. A majority of economists working in the field of environmental and resource economics believe natural resource values that are independent of people's present use of resources have been termed as existence, intrinsic, non-use values. These values are said to arise from variety of motives like desire to bequeath environmental resources to next generation theoretical framework.

4.2. Definition

The concept of non-use values into the mainstream of economics literature was introduced by John V. Krutilla. In his classic article "Conservation Reconsidered" he argued that consumers need not be active consumers of a resource. Its willingness to pay can be captured by a price discriminating monopoly owner in order to derive value from the continuing existence of unique, irreplaceable environmental resources. Krutilla suggested two reasons people hold values apart from their present use. One of them is to preserve options for future use and the other is bequeathing natural resources to their descendent. An option demand may exist not only among persons currently and prospectively active in the market for the object of the demand, but among others who place a value on the mere existence of biological or geomorphologic variety and its widespread distribution. According to McConnell the notion that a good is valued only for its existence that it provides no in situ services, is farfetched. Existence value occurs only insofar as bequest or altruistic notions prevail. Resources are needed because they are valued by others of your own generation or by our heirs. Thus, use value is the ultimate goal of preferences that yield existence demand, though the existence and use may be experienced by different individuals. People can have what are essentially existence values out of an unethical or altruistic concern for the status of non-human species or proper rules of human conduct. The philosophers of ethics do not agree to the validity and proper form of such concerns. It is possible that some people hold such values and are willing to commit resources on the basis of those values. Such values could be entirely independent of any human use of the environment.

As a result, environmental goods can broadly be classified as;

I. Use Value II. Non-use Value

I. Use Value:

Conventionally use value of an environmental good includes its present use, (we are currently visiting the wild life sanctuary), expected use (we plan to visit the sanctuary later this month) and possible use (we might visit the sanctuary in coming five years) This possible use of environmental good like some remote forest which is hardly visited by people would create long term use if the possible use is taken into account. The use value of environmental good therefore opens up another notion of human impact where environmental goods impact human either directly or indirectly Direct health effect of air pollution (an environmental bad) would result in mortality (death) or morbidity (illness). An indirect impact from air pollution could be non-health effects like noise visual impacts, bad odors etc. For example, if you have come to enjoy an exotic place, smoke coming from a power plant would result in brown plume harming the ambience you have come to enjoy. In such cases there may not be much physical impact due to this plume but this has created a hurdle by making the view annoying. The consumer would in turn be ready to pay some amount to get rid of this plume and hence creates an opportunity cost .This is same economic cost just like health effect from production side, the cost of pollution may enter the production function directly. This affects the process of production adversely for example air pollution may make the production of microchips really costly as they now require super clean conditions as a result of air pollution Further environment goods lead to material damage. Air pollution may damage or soil buildings implying excessive maintenance or cleaning cost. Another sphere of concern of environmental goods to human impact is via ecosystem damage Fisheries, forests agriculture, natural environment all together create our ecosystem from this ecosystem, humans directly derive benefits which are economic benefits in real terms .Environmental pollution would definitely degrade the efficiency and performance of these ecosystems. Urbanization which leads to pollution would disrupt the ecosystem of a national park .This would have

harmful effect on the recreational value of national park by reducing its economic value.

Apart from recreational use, ecosystems have further benefits like they are the source of genetic material or input used in manufacturing new pharmaceuticals. Measuring the value of ecosystem benefits or services has emerged as a significant controversial area of valuation. This is because there are difficulties in determining measurable or tangible impacts related to damage of ecosystem. For example, one of the harmful impacts is the disruption of ecosystem due to environmental pollution, which is a reduction in the number of species. This would have a long-term impact on mankind in the future. This aspect of disruption of ecosystem and its impact on mankind as a consequence is usually ignored and underemphasized. U.S. Environmental Protection Agency (2009) developed.

II. Non-use Value:

Non-use value is a most debated aspect of classification of environmental goods. Non-use value is defined as a gain to a person enhancing person's utility without the person actually utilizing the good or its services directly. It rather refers to applying the word "using" very broadly. In this case of non-use value, one may value an ecosystem in a remote area without revealing or intending to visit the place or deriving any material benefit from the use of the ecosystem. Similarly, one may value a blue whale swimming freely in an open ocean despite of having no intention of seeing the blue whale ever. Non-use value is further classified into three types: existence value, altruistic value, and bequest value. Existence value is the value a consumer perceives just by knowing that something exists, for example, the value one places on a wild life sanctuary in Africa. The pleasure one derives while knowing the wild life existence in that remote area. This is in addition to any value associated with potential or actual use. Altruistic value is the value derived not from one's own consumption but from the fact that others or someone else would derive utility. Keeping the yard clean in front benefits your neighbor and you obtain utility from the fact that your neighbor is better off. Bequest value is almost the same as altruistic, that is, deriving happiness or utility when others are better off. Bequest value accounts for the wellbeing of future generations. If you value

passing on the natural wild life on to the next generation, then the wild life forest has a bequest value to you, even though you would not use that area in any way, there is no direct materialistic use of that area Finally the purpose of categorizing the environmental goods according to use and Non-use value is to comprehend the difficulty and dichotomy of assessing the value of these environmental goods much of the environmental assets confer value on the consumers looking at their use value. But coincidentally many environmental assets have very less use value but instead have significant non-use value.

4.3. Valuation Methods

Environmental goods though valuable and useful for economic agents living in society do not have well defined markets. This non-existence of market for these goods creates problem in measuring demand of environmental goods. There are two basic approaches to measuring demand of environmental goods.

1. Revealed preference Methods
2. Stated preference Methods.

1. Revealed preference Methods, real choice is observed in the prevailing markets and thus the trade-off between money and the environmental goods is inferred or derived. For example, it is possible that if there are two identical communities but with only one difference that one of them has higher prices of houses, these high house prices are associated with clean air while in the other community the prices are lower reflecting low quality of air or dirty air

In revealed preference method, there are two approaches for measuring demand.

- A. Hedonic Production Function Approach
- B. Household production Function Approach

A. Hedonic Production Function Approach

In Hedonic approach the aim is to observe how price of a usual or marketable good example house varies with a closely related environmental good like air quality around the location of the house. The relationship between the house and the air quality around the house is then used to measure the value of environmental good i.e air quality In this method price of a commodity is a function of characteristics it possesses For example land

has different characteristics in terms of location , size and environmental quality in its vicinity Similarly different jobs have different characteristics in terms of risk involved like on job accidents , training and enhancement of skills , local environmental quality etc. By observing changes in the price of marketable good with respect to changes in characteristic of good an economic agent pays a price or premium for a particular characteristic of a good. This creates the underlying notion or proposition for hedonic approach various environmental characteristics like air, water quality affect the price of the good like land or houses. Consider a good with single characteristics for example houses with different levels of characteristic such as number of room or pollution levels, this involves determining the price of good in the market and deducing the consumer willingness to pay for changes in the characteristic.

The first step is to identify a single homogeneous area such as a city, that can be considered as single market from point of view of our good that is house Each house is characterized by a single variable q which is air quality level The aim is to find $p(q)$ i.e. how the price of house varies with pollution levels In order to find $p(q)$ we need to consider both consumer side and producer side of the market We assume that market is competitive implying both producers and consumers.

The Consumer Side

Consider a consumer with utility function U and income M The consumer buys only one house The consumer spends his income on consumer good X with nominal price 1 and environmental quality q . Therefore, utility is given by $U(X,q)$ Let λ be the maximum amount of money consumer is ready to bid U^* is the desired utility The objective is to maximize λ Such that

$$U(X, q) \geq U^*$$

Subject to budget constraint

$$X + \lambda = M$$

Consumer chooses the maximum he can bid for the house achieving maximum utility given the budget constraint. Finally given the values of q , M and U^* we determine how much money is available for the house. $\lambda (M,q,U^*)$

is called the bid function as it reflects the amount of money consumer is willing to bid for the house with characteristic q level of air quality. If this exercise is repeated for another consumer with different income, then different set of bid functions are obtained the consumer's problem is to obtain that level of air quality q that maximizes his utility The price line is given by $p(q)$ so the optimal point for consumer is the point at which bid function is tangent to price function $p(q)$.

The producer side:

On this side of the market there are producers of the houses. Different producers have different costs. The producers specialize in different segments of housing If we consider a producer with a given cost structure assuming it follows constant returns to scale therefore deriving the cost of producing one house of characteristic q . Suppose the producer faces input prices w and unit cost given by $c(w,q)$.If the producer offers a price of α , then profits per house are given by $\Pi = \alpha - c(w, q)$.

Given the level of characteristic q the level of profit function can be obtained as $\alpha(w, q, \pi)$ This is referred to as offer function. The offer curve indicates the price at which the producer will offer the house in order to attain a particular level of profit given the input price w and level of air quality q If the producer wants to sell a house this offer curve would intersect the price line at a point Finally the above two offer curves of both consumers and producers must have one common point of intersection for attaining equilibrium The tangency point would imply slope of offer curve (of consumers) is equal to bid function (of producers) which is eventually equal to slope of price function $p(q)$ which indicates how much the price goes up when air quality q changes by one unit As a result the basic idea in this method is to observe hedonic price function in the market, later measure the slope then using slope as price of characteristic, we measure demand for the characteristic.

B. Household production Function Approach

Household Production Approach The household production approach starts with the notion that environmental goods do not have market of their own, the consumers therefore combine private goods with environmental good to produce another good which is of great utility.

A national park could be combined with expenditure to visit the park in order to generate a park visit which is highly valued by people in the society. Therefore the visit to national park must be worth at least the travel expenditure. By observing expenditures on the complementary good private in nature we derive the lower bound on the value of environmental good. One of the versions of household production approach is household health production function. This function can be used to estimate the value households place on benefits of reduced morbidity and mortality due to reduction in air and water pollution. When the health changes occur as a result of environmental factors, the change in the productive activity can be measured and valued. Another version of household production function is Travel Cost Method. It is basically used to value recreational benefits like parks and natural areas. The underlying assumption or notion is that there is weak complementarity between the demand of environmental good and private good like travel. In this method, the utility of an individual depends on total time spent at the park or the natural area, the quality of the location and the quantity of composite private good other than travel with the duration of visit as fixed, the time spent on the location is represented by number of visits.

The individual maximizes the following utility function

$$U(X,r,Q)$$

Subject to budget constraint

$$M + p_w t = p_x X + c \cdot r$$

$$t^* = t_w + t \cdot r$$

Substituting the time constraint into the budget

$$M + p_w t = p_x X + p_r r$$

Where p_r is the full price of a visit given by

$$p_r = c + p_w \cdot t = f + p_{dd} + p_w t$$

Where;

X: the quantity of private good other than travel consumed by the person

p_x : price of the private good.

r: is number of visits to recreation site.

Q: environmental quality at the site.

M: exogenous income.

pW: wage rate c: monetary cost of a trip.

t*: total discretionary time.

tw: hours worked.

t: round trip travel time.

f: admission fees.

d: distance in Kms covered in the trip.

pd: cost of travel per Kms.

Maximization of utility subject to budget constraint would yield individuals demand function

$$r = r(p_r, p_x, M, Q)$$

The travel cost method can be used to estimate demand for recreational services offered by environmental natural resource.

2. Stated Preferences Methods

The Stated preference approach is of stated preference. This method involves asking people about the trade-off between money and environmental good if they were given the chance to do this. There are various methods used in order to take this account of trade-off. Opinion polls and surveys are used to obtain this information The experience exhibits that this approach is controversial as this approach is not based on real choices therefore there are no actual trade-offs or actual trade between money and environmental goods further this theory is based on hypothetical choices so the information provided may not be accurate There exists a great deal of debate and controversies among economists to accept this method of valuing environment because choices are not real, they are hypothetical. Existence of experimental markets reflect the characteristics of both approaches in experimental markets people are given money and they are asked to make their choices as a result in such cases decisions are real.

In the regime of stated preferences most prominent approach is termed as Contingent valuation method. This method depends on direct revelation of demand from consumers. It means the value given to the environmental good contingent on there being a market i.e, if there were a market then how much amount would be paid for the environmental good It is a kind of constructed market in which a researcher will generate or construct a market given a

situation when no market exists Contingent Valuation Method is a survey based tool The survey instrument seeks to create a hypothetical market and response to this market allows the researcher to estimate respondent's values associated with environmental goods These constructed markets can be real or hypothetical Many times laboratory experiments are also widely used to generate the information on how people can trade money for environmental goods Laboratory experiments are useful for extracting data that are otherwise nowhere available. Such experiments may involve real decisions involving monetary transactions. This includes example of creating market for buying and selling of permits for duck hunting these experiments are very costly to hold or construct and involve non-random selection of samples like students from related fields therefore it is difficult to generalize the results Another type of constructed markets is official referendum under such markets idea is to provide some environmental good using a tax on residents of a community. Here the proposal is put forward in front of the voters which lead to real choice situation. Its application is limited to environmental goods offered in the community through referenda Further, another approach emerged is known as "benefits transfer" "This is poor man's approach" to valuation of benefits. This is used when researcher does not have resources to conduct any experiment or a study then literature survey can help find similar analyses and can transfer them to their application.

4.4. Contingent Valuation Method

In contingent valuation method, the consumers are directly asked how they would value for an environmental good, if there would be a market situation. So, we need to understand that this market is purely hypothetical in nature because we are actually putting this scenario as if there were a market; that means, it is conditional one. If there were a market, then what the consumers would be interested to pay for an improvement in an environmental good, but, actually there is no market for it. So, this market is just a hypothetical one, we need to imagine that as if a market exists for this type of environmental good so that we can capture if the quality or quantity of an environmental good increases, then how we are going to pay for particular environmental good, by asking the consumers a set of questions regarding their preferences

directly to them. In stated preference method, we directly pose the questions to individuals or the beneficiaries and can get to know their willingness to pay. Therefore, the stated preference methods are the survey-based methods. The real task is to develop the contingent valuation questions or questionnaire. In developing contingent valuation questions, the individual is asked to imagine some situation, that is typically not available and that is outside individuals experience because it is not real, it is a really highly hypothetical. And, then the individual is asked to speculate on how he or she would be reacting in a particular situation of increase or decrease in the quality or quantity of an environmental attribute. In CV questions, we develop some hypothetical questions, which are imaginary in nature are based on a particular theme or a particular situation that we want to picturize. The CV method has its application since 1960s. So, first by Davis in 1963 and Randall and their co-authors also developed CV method in 1974.

CV method uses a direct approach. So, it basically asks individuals what they are willing to pay for a for a particular benefit or what they are willing to receive or accept by way of compensation, if they are not going to get the benefit and they have to tolerate the costs. The first mode of CV survey could be in terms of direct questionnaire or direct survey. The second one could be in terms of experimental techniques.

Let us understand the components of the contingent valuation survey. So, in this contingent valuation survey, we need to see what the compensation amount is or what the willingness to pay amount. And in order to accept compensation or willing to pay, we must actually be able to administer or we must able to design the mechanisms and interpret the survey in a right manner.

We can divide the survey typically into three parts. First, we need to highlight the background information of the study on the particular environmental good. So, what exactly would be the environmental attribute we are interested to value? Second, the sections on eliciting the value. And the last one can be in terms of asking background information on the on the respondents or the individuals whom we are putting the questions on environmental goods or environmental attributes. So, these are basically three different sections,

which must be present in a typical contingent valuation questionnaire. Let us discuss the components for conducting a successful CV survey advocated by Carson. The first one is defining the market scenario what exactly we are going to value so that we can create that kind of market. And, the second one would be the choosing the elicitation method. So, what would be the medium of elicitation value and how to design the market administration, how to design the sampling, then designing the experiment and finally, estimating the willingness to pay functions on the particular market scenario based on the environmental attributes in discussion. And, the second one would be the choosing the elicitation method. So, what would be the medium of elicitation value and how to design the market administration, how to design the sampling, then designing the experiment and finally, estimating the willingness to pay functions on the particular market scenario based on the environmental attributes in discussion. Another method is the discrete choice method or which is also known as the referendum choice. The willingness to pay amount is offered to the respondent. And then we are asking that whether he is willing to pay the amount. And, again for different respondents based on their socio-economic characteristics, we are offering different willingness to pay figures and then will be getting a very possible range of willingness to pay amounts. So, that can also be taken into account. And, finally, the final step in the CV study is estimation of willingness to pay functions and we need to analyze the survey results and estimate what is the willingness to pay. So, we need to take into account the socio-demographic characteristics of the individuals or respondents, we need to take into account their behavioral attitudinal responses and what are the characteristics or what are the improvements we are actually conveying to them and what would be their willingness to pay in order to get these increased environmental qualities.

4.5. Economics of Sustainable Development

Economic sustainability is expressed in terms of sustainable capitals like man-made capital, natural capital, human capital and social capital. So, the task is how all these forms of capital can be sustained, can be maintained throughout the time? Sustainable use of renewable natural resources can be produced if economic sustainability is maintained. And moreover, we need to

think about the use of non-renewable resources by the future generations and the rate of depletion of the non-renewable energy sources that must be taken into account in order to understand economic sustainability. And finally, economic sustainability means how to optimally use and manage the resources.

Economic sustainability, we consider growths needs to be sustained, profit needs to be continued for longer time. We need to focus on resource and development for increasing the quality of the products. If all these dimensions are fulfilled then, we will be having an integrated whole of the sustainability; what we call is the three pillars of sustainability. Likewise, when we are taking the economic sustainability and environmental sustainability and their intersection point, it talks about the environmental and economic sustainability related to: How energy will be efficiently used or how should be the renewable fuels are used, what is the alternatives, the policies that promote for subsidizing a particular resource, giving incentives, how to stop pollution or how to use less of this natural resources, how to promote green technology so that the resource efficiency can happen. So, all these examples are dealing with the environmental, as well as economic sustainability. And the last intersection point between societal sustainability and economic sustainability is reflected. For example, we can take the business ethics or how the workers can be benefited taking to account the societal welfare and the economic sustainability. If workers' benefits are taken into account, workers are paid after work then the societal well-being is encouraged and also the economic sustainability in terms of growth or in terms of profit can be maintained.

We need to also understand the typology of the sustainability, which can broadly be divided into these two parts. The first one is the weak sustainability and the second one is strong sustainability. So, what is this weak sustainability and what is the strong sustainability, what is the basis of sustainability classification?

Again, the basis of this categorization of sustainability is based on different schools of thought on the concept of sustainability itself. The idea of weak sustainability can be found from the pioneering work of Robert Solow in 1974,

a neoclassical economist and a Nobel laureate. And this the same idea of weak sustainability can also be found from the works of John Hartwick, in 1977, another Nobel Laureate.

What is their viewpoint of this weak sustainability or what is the meaning of weak sustainability? So, the very idea of weak sustainability is that the man-made capital and the natural capital are substitutes; that means, if the amount of natural capital is decreasing, then you can increase the man-made capital in order to substitute it, in order to fill the gap of natural capital and this is possible. So, in this context if we are believing in the weak sustainability; that means, we can substitute the natural capital for man-made capital and vice-versa, the depletion in the natural capital like natural resources can be easily accommodated by investment in the man-made capital.

Strong sustainability is based on the assumption that natural capital and man-made capital are complementary not substitutes of each other. And as they are complementary, they cannot be substituted for any economic activity. We cannot say that the amount of the natural capital can be decreased and the amount of man-made capital is increased to carry forward a particular economic activity with no issue. So, because these forms of capital are complementary and that is why they cannot be substituted.

4.6. Green Accounting

The Net National Product (NNP) is still the best welfare measure under standard national income accounting. But the present system of national accounting i.e. NNP fails as a measure of sustainable development as it does not take into account the use and abuse of natural resources. While considering the allowances for consumption of capital in calculating NNP, it gives consideration only to depreciation of man-made capital and ignores depreciation of natural resources – non-renewable, renewable resources, pollution etc. The present SNA suffers from certain deficiencies. These are: i. The SNA takes note of only such production and consumption processes where there is market price. ii. It does not impute the values of environmental goods and services used in production process and iii. It also does not

consider any allowance for depreciation/degradation or depletion of natural resources. The Green accounting of income is an attempt or method to correct the present measure of NNP for use and abuse of natural and ecological resources to arrive at sustainable income which can be a measure or indicator of sustainable development. The improvement in the methods of SNA was debated in the 1992 United Nations conference on Environment and development (UNCED) held at Rio de Janeiro, which recommended all nations to develop a system of Integrated Environmental and Economic Accounting (IEEA)- which came to be known as green accounting.

The main objective of IEEA is to expand existing system of national economic accounts in order to integrate environment and social dimensions in the accounting framework. Alternatively, at least satellite systems of accounts for natural resources be developed to arrive at what is currently being coined as 'Green GNP.' In practice, it is difficult to develop an accounting for natural resources. Parikh and Parikh (1997) elaborated on the system of Environment and Economic accounting as developed by the United Nations and provided a definition of Green NNP as – $\text{Green NNP} = \text{Value of consumption of natural goods and services} + \text{value of production of natural collected (such as fuelwood, biogas)} + \text{value of environmental amenities provided by environmental resources stocks (such as clean air, top soil)} + \text{value of leisure enjoyed (Say in enjoying aesthetic beauty of wildlife revenue)} + \text{value of net additions to production of capital} + \text{value of net addition to natural capital stock} + \text{value of addition to stocks of defensive capital (such) as water purifier}$. Thus, NNP is the total income earned by the economy in any year, less an allowance for the depreciation of manmade capital. Green NNP or environmentally adjusted NNP is a good measure of sustainable development as it induces – (i) all elements of NNP correctly valued in terms of current economic situation; (ii) when this is true in a forward-looking sense too (prices reflect future scarcity) and (iii) when all depreciation of natural capital is similarly allowed for as well. Thus, Green NNP is the annual pay-off from our total capital stock (manmade + natural). ENP can rise over time if this total capital stock rises and /or as technology improves. According, Hartwick rule, the total stock of capital can be maintained by reinvesting hotelling rents

(price-MC) from optimal non-renewable resources infraction planning new natural or manmade capita. So, the indicator of sustainability is non-declining ENP, or whether ENP is rising or falling. If ENP is falling, and then society's sustainable level of income is falling too. Development is unsustainable.

4.7. Ecological Foot Print

Ecological footprint is a metric that measures two things. These two things take into account both the supply and the demand factors so far the ecology is concerned. By taking into account demand and supply factors, ecological footprint may be defined as how much nature do we have? And how much nature do we use? 'How much nature do you have' is the supply side factor. The demand side signifies the very dependence of the human beings or the whole mankind on the natural resources. What is the quantity of nature that we are using? The supply side factor talks about how much nature do we have? It implies to productivity or bio capacity of the environment as well as the ecology for catering to the needs of demand side. In a nutshell, ecological footprint can be measured by taking into account the demand for the goods and services by human beings from nature. We are also measuring the supply side factor by taking into account the amount of the bio capacity or productive ability or productivity of the very ecosystems on which the human beings are depending.

In ecological foot print concept, we are quantifying the ecological assets. What are ecological assets? We are categorizing ecological assets into six different groups. So, these are the crop lands, grazing lands, fishing grounds, built up lands, forest area, and the carbon demand on land. These are the six categories ecological assets we have taken into account. And we are demanding in terms of goods and services from these six ecological assets. So, when we are measuring the demand on nature by taking into account all these categories. We are also measuring the demand on nature by taking into account the waste absorption of nature. These wastes are generated in our economic activities in terms of pollutions and negative externalities or unwanted output, which are automatically absorbed in nature up to a point. The absorption capacity of nature can assimilate the waste. And on the supply

side, we take into account the bio capacity of a particular area or particular geography a geographical location. Let us say we are talking about a particular state, a region, or nation, or some international boundary and continents. The bio capacity of these regions represents the very productivity of the ecological assets.

4.8. Carbon Foot Print

A carbon footprint (or greenhouse gas footprint) is a certain amount of gaseous emissions that are relevant to climate change and associated with human production or consumption activities. In some cases, the carbon footprint is expressed as the carbon dioxide equivalent (CO₂e) which is meant to sum up the total Green House Gas (GHG) emissions caused by an individual, event, organization, service, place or product. In other cases, only the carbon dioxide emissions are taken into account but not those of other greenhouse gases. IPCC uses the following definition for carbon foot print: “Measure of the exclusive total amount of emissions of carbon dioxide that is directly and indirectly caused by an activity or is accumulated over the life cycle stages of a product”.

The concept and name of the carbon footprint was derived from the ecological footprint concept. While carbon footprint is usually reported in tons of emissions per year, ecological foot prints are usually reported in comparison to what the planet can renew. This assesses the number of earths that would be required if everyone on the planet consumed resources at the same level as the person calculating their ecological footprint. The carbon footprint is one part of the ecological foot print. Carbon footprints are more focused than ecological footprints since they merely measure emissions of gases that cause climate change into the atmosphere.

4.9. Ecological Shadow

The term “Ecological Shadow” refers to the hidden or indirect environmental impact of human activities impacts that occur outside the area where those activities take place. In other words, it’s the ecological footprint that’s displaced elsewhere due to global trade, consumption, and production patterns. “The environmental damage and resource depletion that occur in one region or country as a result of consumption or production in another.”

The concept of ecological shadow refers to the indirect or hidden environmental impact created by human activities, particularly those resulting from patterns of production, trade, and consumption that extend beyond a specific locality or nation. It highlights how the environmental costs of economic growth and consumption are often shifted or displaced from one region to another. In a globalized world, many developed countries maintain high levels of consumption, but the environmental degradation and resource depletion linked to this consumption often occur in developing countries where the goods are produced. This creates what is known as an ecological shadow—the unseen area of environmental damage that falls outside the direct boundaries of the consumer region. For example, industrialized nations import raw materials, food, and manufactured goods from developing countries. The deforestation in the Amazon for soybean cultivation, water pollution from textile industries in Asia, or mining pollution in Africa are not directly visible to consumers in Europe or North America, yet they are part of the ecological shadow of their consumption patterns. Similarly, the export of electronic waste from developed to developing countries also casts an ecological shadow by causing toxic contamination and health hazards. The concept emphasizes that environmental problems are interconnected and global. It reveals the inequality in environmental burdens—where the benefits of consumption are enjoyed by one part of the world while the ecological costs are borne by another. Recognizing ecological shadows helps in promoting sustainable development, responsible trade policies, and shared environmental responsibility among nations.

In summary, the ecological shadow is the unseen environmental footprint that extends beyond national borders. It reminds us that no country or individual can be truly sustainable while depending on activities that degrade ecosystems elsewhere. Therefore, understanding and addressing ecological shadows is essential for achieving global environmental justice and sustainability.

Check Your Progress:

Q.No	Short Questions	LOCF Mapping		
1.	Summarize the concept of total economic value.	K2	CO3	PO3
2.	Explain the travel cost method with an example.	K2	CO2	PO2
3.	Describe the hedonic pricing method used in environmental valuation.	K2	CO2	PO2
4.	Define carbon foot print and explain its environmental implications.	K2	CO4	PO4
5.	Examine the importance of ecological shadow.	K5	CO2	PO4
Q.No	Essay Type Questions	LOCF Mapping		
1.	Discuss the concept of total economic value and its components in environmental valuation.	K4	CO3	PO3
2.	Analyze the contingent valuation method and its usefulness in environmental policy decisions.	K4	CO2	PO3
3.	Examine the travel cost model as a method of valuing recreational resources.	K4	CO2	PO3
4.	Critically discuss the concept of green accounting in measuring sustainable economic development.	K5	CO4	PO4
5.	Apply environmental valuation techniques to estimate the value of a national park.	K3	CO2	PO2

UNIT – V

ECONOMICS OF POLLUTION CONTROL

5.1. Introduction

There is general agreement that we must control pollution of our air, water, and land, but there is considerable dispute over how controls should be designed and how much control is enough. The pollution control mechanisms adopted in the United States have tended toward detailed regulation of technology, leaving polluters little choice in how to achieve the environmental goals. This “command-and-control” strategy needlessly increases the cost of pollution controls and may even slow our progress toward a cleaner environment. In 1970, popular concern about environmental degradation coalesced into a major political force, resulting in President Richard Nixon’s creation of the federal Environmental Protection Agency (EPA) and the first of the major federal attempts to regulate pollution directly the Clean Air Act Amendments of 1970. Since then, the federal role in regulating pollution has grown immensely, unleashing many regulatory responsibilities on the EPA and a cascade of regulations on local governments and the business community. But that has begun to change somewhat as environmentalists have increasingly realized that markets can work to allocate pollution reduction responsibilities efficiently among firms and across industries. Although the command-and-control approach is still the norm, environmental lobbyists and legislators have, on occasion, considered market-based approaches to pollution control. Most of the proposals for limiting global warming, for example, explicitly include market-based approaches for controlling carbon dioxide emissions.

5.2. Optimal level of pollution

The economic definition of pollution is dependent upon both some physical effect of waste on the environment and a human reaction to that physical effect. The physical effect can be biological (e.g. species change, ill-health), chemical (e.g. the effect of acid rain on building surfaces), or auditory (noise). The human reaction shows up as an expression of distaste, unpleasantness, distress, concern, anxiety. We summarise the human reaction as a loss of welfare. We now need to distinguish two possibilities for the economic

meaning of pollution. Consider an upstream industry, which discharges waste to a river, causing some loss of dissolved oxygen in the water. In turn, suppose the oxygen reduction causes a loss of fish stock in the river, incurring financial and/or recreational losses to anglers downstream. If the anglers are not compensated for their loss of welfare, the upstream industry will continue its activities as if the damage done downstream was irrelevant to them. They are said to create an external cost. An external cost is also known as a negative externality, and an external diseconomy. If we were considering a situation where one agent generates a positive level of welfare for a third party, we would have an instance of an external benefit (positive externality, or external economy). An external cost exists when the following two conditions prevail:

1. An activity by one agent causes a loss of welfare to another agent.
2. The loss of welfare is uncompensated.

Note that both conditions are essential for an external cost to exist. For example, if the loss of welfare is accompanied by compensation by the agent causing the externality, the effect is said to be internalised. This distinction will be made clearer shortly.

Optimal Externality

The first fundamental feature of the different definitions of externality has already been noted: the physical presence of pollution does not mean that 'economic' pollution exists. The next observation is equally important, but much less easy to understand - even if 'economic' pollution exists it is unlikely to be the case that it should be eliminated. In Figure 5.1, the level of the polluter's activity, Q , is shown on the horizontal axis. Costs and benefits in money terms are shown on the vertical axis. MNPB is 'marginal net private benefits'. A formal derivation of MNPB, in the context where the polluter is a firm, is given in Appendix 5.1. But an intuitive explanation is also possible. The polluter will incur costs in undertaking the activity that happens to give rise to the pollution, and will receive benefits in the form of revenue. The difference between revenue and cost is private net benefit. MNPB is then the marginal version of this net benefit, i.e. the extra net benefit from changing the level of activity by one unit. MEC is the 'marginal external cost', i.e. the value of the extra damage done by pollution arising from the activity measured

by Q . It is shown here as rising with output Q . We consider other possible shapes for MEC in figure. We are now in a position to identify the optimal level of externality. It is where the two curves intersect, i.e. where $MNPB = MEC$. Why is this? We first offer an intuitive explanation. Since the two curves are marginal curves, the areas under them are 'total' magnitudes. The area under MNPB is the polluter's total net private benefit, and the area under MEC is total external cost. On the assumption that the polluter and sufferer are equally deserving - i.e. we do not wish to weight the gains or losses of one party more than another's - the aim of society could be stated as one of maximising the sum of benefits minus the sum of costs. If so, we can see that triangle OXY is the largest area of net benefit obtainable. Hence, Q^*

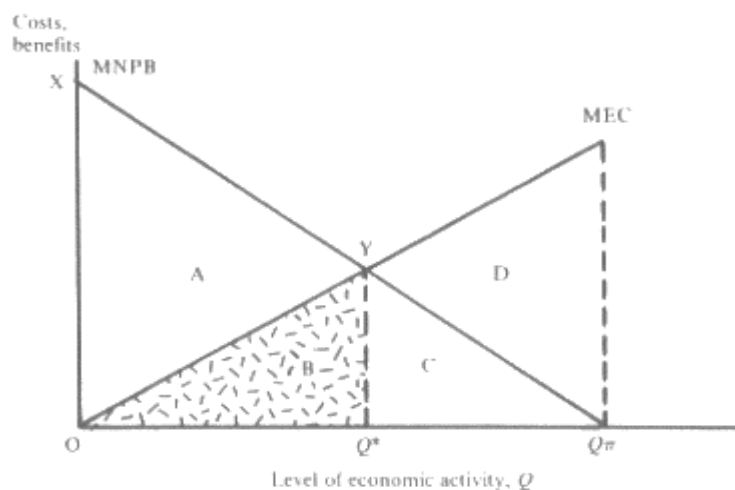


Figure 5.1 Economic definition of optimal pollution

Economic definition of optimal pollution is the optimal level of activity. It follows that the level of physical pollution corresponding to this level of activity is the optimal level of pollution. Finally, the optimal amount of economic damage corresponding to the optimal level of pollution Q^* is area OYQ area B in Figure 5.1. Area OYQ is known as the optimal level of externality.

This result can also be derived formally. At Q^*

$$MNPB = MEC \text{ but}$$

$$MNPB = P - MC$$

where MC is the marginal cost of producing the polluting product.

$$\text{Hence } P - MC = MEC$$

$$\text{or } P = MC + MEC$$

Now, $MC + MEC$ is the sum of the marginal costs of the activity generating the externality. It is marginal social cost (MSC). Hence,

$$MNPB = MEC, P = MSC$$

'Price equals marginal social cost' is the condition for Pareto optimality. We do not demonstrate this here any undergraduate microeconomics or welfare economics text should contain a proof.

5.3. Regulation of Pollution through Economic Instruments

Human beings perform many activities for their survival, economic and material growth, safety and security. When we produce different kinds of goods and services to meet our requirements, some wastes are also released into the atmosphere. Many times, in the absence of regulations, producers ignore the wastes and do not treat them before releasing them into the atmosphere. These anthropogenic activities generate pollution. The environment has a limited capacity to absorb these wastes. The assimilative capacity of the environment is limited. The environment can clean itself up to a certain extent, but if the load of the pollution in the environment is beyond its carrying capacity, it becomes a serious issue and can be dealt with strong regulations. Excessive pollution load on the environment not only adversely affects the carrying capacity of the environment, but also affects our well-being. Various kinds of ecosystem services are badly affected due to environmental degradation. That is why it makes a strong justification for environmental protection through regulations.

Let me now explain why the regulation is required. In our daily life, we face different kinds of regulation. As a student, you have several academic regulations to comply with, such as attendance regulation. Similarly, when we go to the market to buy a particular product, we are not aware of the quality of the product. To ensure that the quality of the product is up to the mark, regulation is required. The producers have to produce as per the specification mentioned in the product. Economic regulation involves government interventions in a variety of ways in the private action of firms and individuals. Not only the regulation is required to control the activities of producers, but sometimes we also have regulation to regulate the activity of

consumers. Consumers also release wastes when they consume goods and services.

The different kinds of instruments, through which regulation is done by the government. Broadly, environmental regulations can be classified into two categories - command and control and economic incentives. The command-and-control approach is known as direct interventions in the activities of the polluters, while the economic incentives are indirect interventions in their activities. The economic incentives are also known as the market-based approach to protecting the environment.

The command-and-control approach is a direction by the government in the way in which production and consumption activities are carried out. So, the government can control through regulations both the producer's and the consumer's activities to achieve the intended goal of environmental protection. The government enacts several rules and regulations. The enactment of rules and regulations is part of the command-and-control mechanism. The government institutes enforcement of authorities at different levels to implement them. The institutional framework can be set up to implement the regulations, and place a system of fine and penalties for dealing with the case of violation of rules and regulations. I can cite the recent initiative taken by the government of India that is the Motor Vehicle Act, which is a good example of regulation. Different kinds of fines are being imposed on those who are violating the rules. If you are not using your seat-belt, the fine will be imposed. If you are driving your car and also talking on mobile, the fine may be imposed. So, it is a kind of regulation. However, how effectively it will be implemented, that will tell us whether the intended objective of this act will be achieved or not. The major aim of this act is to reduce the accidental death on the road. There may be another way to achieve the same goal. But it is a good example to explain the command-and-control approach of regulation. Similarly, we have many rules and regulations. Under the environment environmental protection act, the CBCB may direct a polluting company to use a specific device or technology to produce the goods. And if that technology or device is not used by the company, it may be punished under the act. The second approach is economic incentives. Instead of

controlling each aspect of the producers, it is better to give the incentive to them not to pollute the environment. Sometimes disincentives may also be given so that environmental protection can be done. The economic incentives or disincentives can be classified into various categories, such as taxes or subsidies. The government can provide subsidies to promote socially actions. In India, subsidies are being provided on solar energy, and the purpose is to produce more energy through the solar system so that pollution/environmental degradation can be reduced. Taxes can be imposed on tax and pollution fees are other options that can be adopted by the government. Marketable permits or tradable permits can be given to the company. Up to a certain extent, the company can pollute the environment. The pollution quota or permits may be given to the polluting companies. If a company is creating pollution beyond its allotted permits/quota, it has to purchase permits from other companies that generate pollution below their allotted permits. The carbon credit is one of the instruments under this. Then, the liability clause can be made. The government can say to the polluter, do whatever you like, but if someone is harmed from your act, it is your liability to pay the compensation. The refundable deposit is also an instrument. Two approaches of environmental regulation the command and control and the economic incentives, which can be used to protect the environment.

5.4. Command and Control Approach

The command and control (C&C) approach is a dominant form of environmental regulation that is being used across the globe. The basic concept of C&C is that the regulator has to specify the steps individual firms/polluters must take to solve a pollution problem. Its essence is that the regulator collects information necessary to decide the physical actions to control the pollution. The regulator, then, commands the polluter to take its specific physical step to controlling the pollution. The regulator directs the polluters on what to do and what not to do. An institutional framework is set up to implement the C&C system. Under this system, the regulator or government directs the polluters to follow the instructions of the government. The governments can set certain kinds of standards related to the environment, and these standards are to be met by the polluters. If the

polluters do not follow the instructions or the standards set by the government, then the regulator can punish them. A penalty can be imposed on them. It is a direct intervention in the activities of polluters.

5.4.1. Define Command and Control:

Under the C&C system, the government enacts the environmental laws and ordinances to regulate the production and consumption of certain activities. It is important to know: why are regulations required? Why does the government enact different kinds of environmental laws and ordinances or regulations to regulate the production and consumption of certain activities? Why is there an emphasis on certain activities? The answers are: First, there are some activities which affect the environment to a greater extent. These activities generate negative externalities or pollutions into the atmosphere. That is why these activities, whether related to the production or consumption of goods and services, must be controlled and regulated through regulations.

Second, to promote people and business entities to bring about a socially desirable behavioral change, the regulation is required. The government tries to change the behavior of the polluters, so that they may take socially desirable actions. Socially desirable actions imply that the polluters must treat the generated pollution before releasing it into the environmental system.

Third, regulation is needed to ensure compliance through enforcement mechanisms. If somebody does not comply with the direction of the government, it can be punished. We have a system of court, police, fine. Different kinds of institutional mechanisms can be set up by the government so that the polluters may comply with the order of the government or the set rules and regulations.

5.4.2. Features of the C&C approach:

The first feature is the restricted choice for the polluter. Under the C&C, the polluters have a limited choice. They cannot decide what kind of technology should be used to produce the goods, it is decided by the government through regulation.

The second is that there is no mechanism for equalizing marginal control costs among multiple polluters. When there are multiple polluters, for achieving economic efficiency, marginal costs of pollution abatement should be equal for all the producers. Under this system, we do not have any mechanism through which the marginal cost of abatement can be equalized among different polluters. This system is preferred over other instruments when the marginal abatement costs of pollution treatment are uniform across all firms in the regulated industry. It is more effective to achieve the intended goals only when the marginal abatement costs of pollution treatment are uniform across all the firms where regulation is made.

In reality, it is not possible because it is difficult to collect information on the cost of abatement of pollution from different firms. That is why it is not feasible for the regulator to decide the emission standard at the level where the marginal abatement cost of pollution abatement is uniform across all the firms in the polluting industry. Due to information, it could be difficult for a regulator to get the knowledge of such costs. Sometimes, information may be manipulated by the companies strategically. They may not share the correct information to the regulators. That is why setting the standard at the level where the marginal abatement costs of all the firms are the same is very difficult and that is why when standards are set generally these aspects are ignored by the regulators.

The third characteristic of the C&C is the centralization of pollution control decisions. The C&C system can concentrate decision-making power in the main authority. Although the authority may have a structure at the lower level, [for example, in India, we have CBCB and the state pollution control board], the strategic decisions are taken by the central authority, such as how much emission standards should be set and what kind of technology should be followed by a particular firm to produce the goods.

5.4.3. Advantages of the C&C system:

1. It is more flexible in regulating the complex environmental process. When the environmental processes are very complex, the economic incentives may not be as effective as the C&C system. In an urban area, where factories at different locations contribute differently to the overall

level of urban pollution, it can be difficult to fashion a workable set of emission taxes or other incentives to ensure a certain level of pollution. In the case of a complex system where it is very difficult to institute uniform tax for all kinds of industries, the C& C system would be more effective as compared to the economic incentives.

2. It has greater certainty in how much pollution control results from the regulation will occur. As compared to the economic incentive like taxes, subsidies or tradable permits, we do not have as much certainty regarding the outcome as the case of the C&C system has because we set the standards and see whether the standards are met. But the problem is in setting the standards. Sometimes standards may be too high or too low from a society's point of view, or socially desirable level of pollution is difficult to be determined by the regulators. But, one thing is clear that once you know the standards, it is easy to monitor whether the standards are met or not. So, there is greater certainty in how much pollution control results will occur after following a particular regulation. It is better than economic incentives in an atmosphere of uncertainty. When there is uncertainty; when you are not sure whether the economic incentives will work or not; the C&C system will provide a better result as compared to the economic incentives.
3. Under the C&C system, monitoring of the compliance is easy. Once the regulator decides the technology or emission standards, the regulator's staff can visit the firms and easily see whether the order is followed or not. For instance, if a particular pollution control equipment is mandated to be installed by the polluters, the staff of the regulator may go to the firm to see whether the specific device/equipment is installed or not,

5.4.4. Disadvantages of the C&C system:

The C&C system of regulation also has certain disadvantages:

1. There is a high cost of collecting information. When the government sets the standards, be it technology or ambient or emission standard, lots of information is required. Getting information may be very costly. Even if the

regulator is able to collect the information; there may be a possibility of getting distorted information from the polluters. Polluters may not share the correct information. The distorted information and high cost of information are the major problems associated with the C&C system of regulation

2. There is no incentive for R and D. In the case of economic incentives; the companies are free to use any kind of technology, and production process. They can spend money on innovations to reduce emissions or to evolve a better resource-conserving technology. In the C&C system company, the polluters do not have an incentive for R and D.

3. The C&C measures are concerned inflexible since they apply the same standards for all the polluters in the industry, often with the same pollution control technology. For example, different car companies may have a different production system, and when standards are set uniformly, the regulator will not be able to get better results.

4. Under the C&C system, regulations are framed by the legislators, who may be subjected to compromises in the political process due to the influence of lobbyists. I already discussed in the interest group theory that many times both browns and greens lobby with the government and try to influence the policy making in their favor.

5. Polluters pay only pollution control, not the residual damage from the pollution. This is another problem associated with the C&C system. In this system, polluters pay only the pollution control cost, not the residual damage from the pollution. Let me take an example, think of paper manufacturing. Paper can be manufactured from the virgin wood, or from the recycled paper. If one firm uses wood coming from the forest to prepare pulp and then paper, and the other firm uses recycled paper, both the firms meet the same standards, but there is a lot of difference. In the case of recycled paper, the firm is saving the environment as compared to the firm which is using forest wood to prepare pulp and then paper.

6. It is also difficult to implement the C&C regulation effectively in the changing level of technology. It is also a major problem associated with this system, especially in those industries where technology changes very fast. In the present era of liberalization and globalization where we are importing

technologies very fast, the production process and technologies are changing very fast. If the standards are kept consistent with the technological change, then the regulator would not be able to get the desired results.

7. Finally, the equi-marginal principle cannot be applied under the C&C system, while in the economic incentives it can be applied.

5.5. Conclusion

Optimal level of pollution is the point where the marginal cost of abating pollution equals the marginal damage it causes, not zero pollution. This is because aiming for zero pollution is often prohibitively expensive, while a higher level of pollution can be inefficient if the cost of reducing it is less than the damage it prevents. Achieving this "optimal" point requires balancing the benefits of a cleaner environment against the economic costs of achieving it, often through policies that internalize the external costs of pollution, such as taxes or cap-and-trade systems.

Check Your Progress:

Q.No	Short Questions	LOCF Mapping		
1.	Summarize the concept of optimal level of pollution.	K2	CO2	PO2
2.	Explain the concept of economic instruments for pollution control.	K2	CO3	PO3
3.	Categorize the various types of economic instruments used to regulate pollution.	K1	CO3	PO1
4.	Discuss the concept of emission standards under command and control policies.	K2	CO4	PO1
5.	Discuss the importance of pollution control for sustainable development.	K2	CO	PO4
Q.No	Essay Type Questions	LOCF Mapping		
1.	Examine the effectiveness of pollution taxes and subsidies in controlling environmental damage.	K4	CO3	PO3
2.	Evaluate the effectiveness of command and control policies in reducing industrial pollution.	K5	CO4	PO4
3.	Critically examine the government policies aimed at controlling pollution through economic measures.	K5	CO4	PO4
4.	Apply the concept of optimal pollution level to explain industrial pollution management.	K3	CO2	PO2
5.	Assess the role of economic incentives in encouraging industries to reduce pollution.	K5	CO3	PO4

Course Outcomes		Programme Outcomes
CO	On completion of this course, students will	
1	Have a better understanding of Environment-Economy Linkages.	PO1, PO2,PO5
2	Apply environmental concepts to Economic Theories.	PO2,PO3
3	Create economic policies incorporating Environmental Issues.	PO5, PO7
4	Analyse the methods to value Environment Pollution.	PO2,PO3
5	Evaluate the need for reduction of Pollution.	PO2,PO7
Textbooks		
1	Karpagam. M, (2017), Environmental Economics–Third Edition, Sterling Publication Pvt. Ltd, Noida.	
2	Nick Hanley, Jason Shogren and Ben White, (2013), Introduction to Environmental Economics, Second Edition, Oxford University Press, Oxford.	
3	Eugene .T Environmental Economics, Oxford University Press, New Delhi. (2014),	
4	Hanley N, Shogren JF, White B “Environmental Economics in Theory and Practice”, 2nd Edition. Palgrave Macmillan, 2007	
5	Kolstad, Charles D, (2000), Environmental Economics, New York: Oxford University Press,	
Reference Books		
1.	Maureen L. Cropper and Wallace E. Oates, “Environmental Economics: A Survey”, Journal of Economic Literature, Volume 30, 1992,	
2.	Barry C. Field, (1994)Environmental Economics: An Introduction, Singapore, McGraw-Hill,	
3.	Hussen, Ahmed.M.(1999), Principles of Environmental Economics: Economics, Ecology and Public Sector. London: Routledge.	
4.	Dr.S.Sankaran(2012) Environmental Economics Margham Publications.	
5.	Mark Maslin(2014) “Climate Change: A Very Short Introduction 3 rd Edition Oxford University Press.	
Web Resources		
1.	https://unfccc.int/	
2.	https://www.undp.org/	
3.	http://moef.nic.in/	
4.	https://www.envis.nic.in	
5.	https://www.unep.org	

Mapping with Programme Outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	3	3	3	3	3	3
CO 2	3	3	3	3	3	3	3	3
CO 3	3	2	3	2	2	3	3	3
CO 4	3	3	3	3	3	2	3	3
CO 5	3	3	3	3	3	3	2	3
Weightage	15	14	15	14	15	14	14	15
Weighted percentage of course contribution to POS	3.0	2.8	3.0	2.8	2.8	2.8	2.8	3.00

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	3	3
CO4	2	3	2	3	3
CO5	3	3	2	3	3
Weightage	14	15	10	13	15
Weighted percentage of Course Contribution to PSOs	2.8	3	2	2.6	3

S-Strong-3 M-Medium-2 L-Low-1

Compiled by:

Dr. K. Ajitha

Assistant Professor of Economics

Manonmaniam Sundaranar University

Tirunelveli – 627 012