UNIT 2 ECONOMY AND ENVIRONMENT

Structure

2.0 OBJECTIVES

After going through this unit, you will be able to:

- describe the concept behind the Material Balance Model;
- indicate the relevance of 'entropy law' to environmental protection;
- discuss the various situations of 'market failure' leading to environmental degradation;
- state the principal characteristics of a well defined 'property rights system';
- explain the importance of Coase Theorem as a bargaining instrument to mitigate the effects of negative externality to environmental resources;
- discuss the limitations of Coase Theorem; and
- outline the significance of 'discount rate' in the context of climate change.

2.1 INTRODUCTION

Environmental resource service is scarce with many conflicting demand placed for it by various human interactions. Since much of economics is concerned with allocating scarce resources to conflicting demands, it has an important role to play in this respect. However, the market system works very poorly in allocating environmental resources. This market failure is largely on account of imperfect specification of property rights, resulting in a set of prices which sends wrong signals to all stake holders (i.e. the producers, consumers and the government). Further, the individual incentive to preserve the environment is often understated in relation to the collective benefit of preservation of environmental resources.

The linkage between economy and natural environment is, however, integral. Every economic action can have some impact on environment, and every environmental change, in turn, can have an impact on the economy. By '*economy*' we refer to the entire set of economic agents (including firms and governments) and the inter-linkages between the agents and the institutions such as the markets. By '*environment*' we mean the biosphere [i.e. *the earth surface on which life exists (Nisbet, 1991)*], the atmosphere, the geosphere (i.e. the part of the earth lying below the biosphere) and all flora and fauna. Thus, the definition of environment includes all life forms, energy, material resources, the stratosphere (high atmosphere) and the troposphere (low atmosphere). These constituent parts of environment interact with each other resulting in changes in environment (an example is the effect of changes in biosphere on the composition of atmosphere). Another example is generation of electricity (the source of energy) from fossil fuel. This type of energy production depletes the stock of fossil fuel from the geosphere besides releasing carbon dioxide (CO_2) and sulphur dioxide (SO_2), both of which result in adverse environmental impact on the quality of life in the long run. The unit deals with these issues by focusing on the relationship between market, market failures and sustainable development.

2.2 ECONOMY-ENVIRONMENT INTERACTION

In economics, environment is viewed as a composite asset that provides a variety of services. Specifically, the environment provides us the life support through three critical services viz. supply of raw materials for production and direct consumption, by acting as sink in absorbing and transforming the economic wastes, and by providing amenities of aesthetic value to the society.

2.2.1 Circular Flow/Material Balance

The inter-linkage between environment and economy can be depicted by a **Circular Flow diagram** (also called the **Material Balance Model**) (Figure 2.1). For simplicity, we define the economy as broadly consisting of two sectors: production and consumption. Exchange of goods and services and factors of production are assumed to take place between these two sectors. Environmental services are primarily rendered through the three interlinked circles E1, E2, E3 and all encompassing boundary labelled as E4. The production sector extracts energy resources (like crude oil, coal) and material resources (like iron ore) from the environment. These are transformed into outputs of goods and services for the consumption as well for further production purposes. Along with these, there is recycling of resources within the production as well as the consumption sectors. Waste material arise at each stage of production as well consumption process. Production process creates waste in the form of industrial effluents, air pollution, water pollution and solid waste while consumption creates wastes by generating sewage, litter and municipal refuse. Thus, the environment's first role is

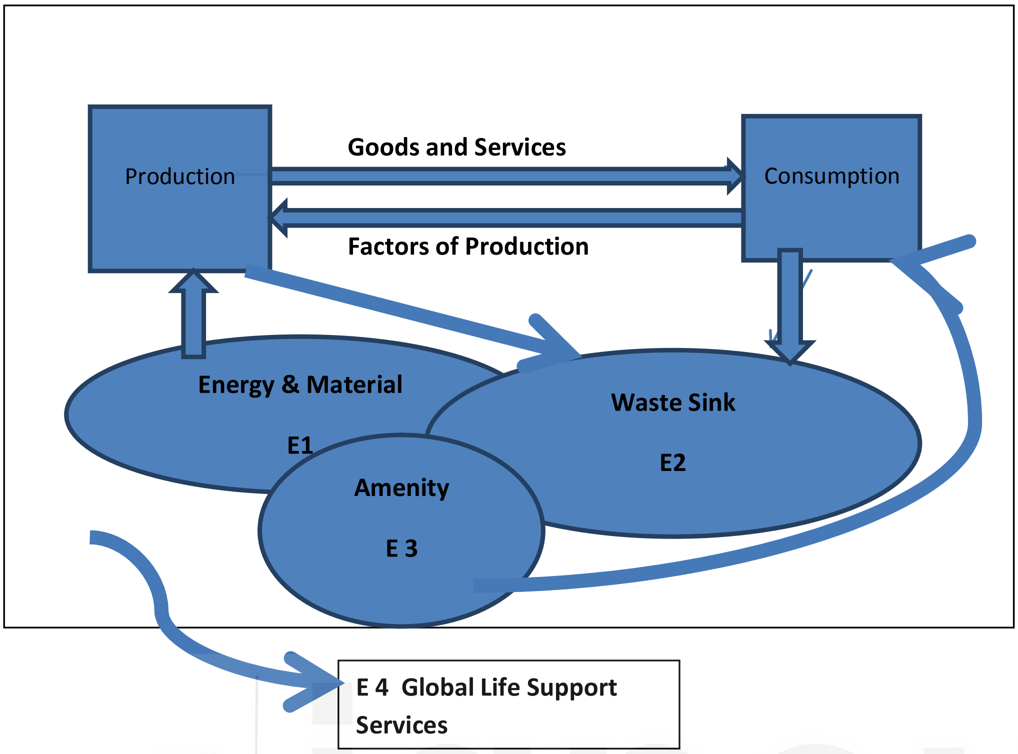

Figure 2.1: Circular Flow Diagram

as a *supplier of resources* where it provides the economy with **raw materials**, which are then transformed into consumer products by the production process with **energy** fuelling the transformation. Its second role is as a **sink** or receptor for waste products. The natural environment functions as the ultimate repository of waste products generated in which gaseous substances like CO_2 and SO_2 go to the atmosphere, industrial and municipal sewage go into rivers and seas, solid waste goes to landfill, chlorofluro-carbons go to the stratosphere and so on. Besides these, the natural systems themselves generate waste like trees shedding off their leaves. However, the basic difference between the waste generated by the two systems (natural and man-made) is that while the natural system tends to recycle their waste (like the dried leaves naturally decomposed in the soil and converted into organic fertilizer for plants and the trees), the waste generated by the economic systems does not have such inbuilt system to absorb the waste by recycling. So the wastes are released into the environment. The environment, however, has a capability limit to absorb the waste and convert them back into harmless or ecologically useful products. This is called the environment's **assimilative capacity** or the **carrying capacity,** which is the second major function of natural environment. The assimilative capacity of the environment is thus a resource which is finite. So long as we dispose of waste in quantities (and qualities) that are commensurate with the environment's assimilative capacity, the economic system will function just like a natural system. But if the disposal exceeds the assimilative capacity we begin witnessing its external manifestation broadly called as **pollution**. We thus have air pollution, water pollution, forest degradation, soil contamination, etc. Excessive waste, when it crosses the assimilative capacity of nature, depreciates the assets or resources by way of reducing their efficiency of service that they otherwise provide. It then starts yielding negative externalities like respiratory problems (caused by air pollution), gastrointestinal diseases (caused by drinking polluted water), nature's beauty getting restricted by smog, etc. The smog effect on nature relates to the third service the environment provides us by way of a wide range of ***aesthetic amenity of spiritual and educational value to the society*** (e.g. majestic mountains, serenity of the wilderness trek, adventure of the wild life sanctuary, mesmerizing view of sunset in the sea) for which no substitutes exist. If we generate more waste, in excess of assimilative capacity of the environment, it will degrade this important function of the environment (e.g. polluted river detracting the amenity value of water flow in the environment). We can look at this from the 'utility-environmental resource-goods/service' perspective as follows.

Individuals derive utility from consuming goods and services and from the state of natural environment. This is by using the natural environment to produce goods and services. To depict this in notation, a representative individual's utility function can be expressed as:

$U_A = U(X_1, X_2, \ldots \ldots X_n, Q_1, Q_2, \ldots \ldots Q_m)$, where,

U_A is the utility, $(X_1, X_2, \ldots \ldots . X_n)$ is the vector of goods and services produced and $(Q_1, Q_2, \ldots . Q_m)$ are environmental assets consumed in the production of the above goods. Q_1 can be local air quality, Q_2 can be local water quality, and Q_m can be the stock of animal population. The environment thus supplies utility directly (to individual A) through the vector of assets and indirectly through its role in the production of 'goods and services'. Clearly, any increase in the output of any element of the X vector will result in the decrease in the quantity or quality of an element in the Q vector. Thus, extracting environmental resources for one purpose (as a supplier of material resource) can reduce its ability to supply for other services (such as the ability to breathe clean air with the reduction in the number of trees). This is the reason why in Fig 2.1, the three circles E1, E2 and E3 are shown as overlapping, indicating the conflicts in resource use. Thus, for instance, using river for waste disposal means its amenity value is reduced besides restricting the scope of fish harvests. Similarly, too much extraction of timber would reduce the electricity generating capacity of a dam, owing to increased soil erosion and reduction in the amenity values due to forest degradation and displacement of wild life.

2.2.2 Laws of Thermodynamics

The inter-linkages portrayed in the circular flow diagram (in Figure 2.1) are governed by the physical or natural laws called the 'laws of thermodynamics' – a branch of science concerned with the relations between 'heat' and 'energy'. Both laws hold true in a strictly closed system with no external inputs. It is grounded in the fact that 'energy' is the basic input on which any economic activity can sustain.

The **first law of thermodynamics,** also known as the *law of conservation of energy* (or the material balance principle) states that 'energy' can neither be created nor destroyed i.e. it can only be transferred (or changed) from one form to another. Hence, whatever we use up by way of resources must end up in some other form in the environmental system. For instance, coal consumption must be equal to the amount of 'energy generated' plus the waste in the form of gases and solids produced by coal combustion. Boulding (1966) construed earth as a closed economic system where economy and environment are characterised by a circular relationship. Hence, we cannot ignore the fact that a closed system sets limits (or boundaries) within which the task of achieving utility for human consumption needs to be considered. The first law has thus two important implications in addition to conveying the significance of limits on matter (i.e. solid, liquid, gas) for supplying energy. One is that, as more matter is extracted by the production process, more of waste is generated. Thus, economic growth which results in increased extraction of material resources (like coal, water, wind, etc.), for generation of energy, is also accompanied by increased residual wastes.

Second, there are limits on the degree to which resources can be substituted for each other in production. The degree of substitutability that can be derived from the environment is a very important parameter referred to in literature on economics as the *'limits to growth'*.

The **second law of thermodynamics** is known as the **Entropy Law.** The word *Entropy* refers in general to the 'degree of disorder', and in the context of energy generation for consumption, its 'unavailability (once used) for new work'. Consider an example of a room cluttered with waste which reduces the utility of the room by its disorderliness. This can be restored only by cleaning up the room which in turn creates more accumulation of waste outside the room. Cleaning up the room makes it transform from a state of high entropy (disorder) to a state of low entropy (order). Linking this to production/consumption of energy in a closed system, which is inevitable and important for economic growth, the use of matter causes a one way flow of energy i.e. from the low entropy resource to high entropy resource (from order to disorder). In a larger perspective, the material that is used in the economy tend to be used *entropically* i.e. the residual gets generated and dissipated within the economic system. In relation to the energy process, this law implies that no conversion of energy, from one form to another, is completely efficient and the conversion process is irreversible. Some energy is lost (i.e. used-up) in conversion and the rest once-used is no longer available. For example, consider a discarded car. Out of the many hundreds of components of car, it is possible to recycle only a few (e.g. aluminium, steel, lead) with a major part not technologically feasible to recycle. In the same way, the carbon dioxide released in the burning process, does not create another useful substance. Entropy therefore creates a physical obstacle. Thus, if the earth is a closed system, with a limited stock of low entropy energy resource (fossil fuel), then the system is unsustainable if the economic activity degrades the energy resources beyond a point (referred to as the 'limit to growth') where no potential for its further use remains.

Although the earth is not a closed system, since we obtain energy directly from the sun too, we have a limited capacity of other energy resources to utilise. Thus, entropy law suggest that the flow of solar energy establishes an upper limit on the flow of energy that can be sustained. And once the stock of stored energy (such as fossil fuel and nuclear energy) is exhausted, the amount of energy available for useful work will be determined solely by the flow of solar energy and further by its amount that can be stored. In other words, over the very long run, the growth process will be limited by the availability of solar energy and our ability to store and use it.

2.2.3 Life Support System and Sustainability

Thus, the natural environment is a very special asset, since it provides **life support system** that sustain our very existence. The three economic functions i.e. (i) resource supply; (ii) waste assimilation; and (iii) amenity and aesthetic value can be regarded as components of one general function of natural environment i.e. the ***function of life support***. The environment also provides services directly to the consumers (e.g. the air we breathe, the nourishment we receive from food and drink, the protection we derive from shelter and clothing) which are all benefits we derive directly or indirectly from environment. The problem we face with the economic designs or systems – whether free, planned, or mixed – offers no guarantee that the life support functions of natural environment will continue to last undisturbed. The working of economic system, under any set-up, risks the running down, depreciation and depletion of natural environment's functions. We, thus, do not have an 'existence theorem' that relates the scale and configuration of an economy to the set of environment-economy interrelationships underlying the economy. But if we are interested in sustaining an economy, it is important to establish the sustainability conditions for the compatibility of economies and their environments.

Check Your Progress 1 [answer the questions in about 100 words in the space given]

1) State the three important functions performed by environment. What, in particular, distinguishes the natural wastes from man-made wastes?

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2) What, in essence, are the implications of the first law of thermodynamics?

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3) What is the implication of the entropy law to the process of energy generation/ consumption? What does this law suggest in respect of this energy issue from a long term perspective?

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4) What is meant by 'function of life support'? What actually is needed to ensure the compatibility of environment with an economic system?

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2.3 MARKET FAILURE IN THE CONTEXT OF ENVIRONMENTAL GOODS

A market is an institution which help agents (buyers and sellers) to exchange goods, services and information through price mechanism. It is a process by which the prices of goods and services are established. Markets facilitate the distribution and allocation of resources in a society. Markets thus use prices to communicate the wants and limits of a diffuse and diverse society so as to bring about coordinated economic decisions in the most efficient manner. The power of perfectly functioning market rests in its decentralized process of decision making and exchange with no omnipotent central planner needing to allocate resources. Rather, prices ration resources to those who value them the most to achieve what is best for the society as a collective. Optimal private decisions based on mutually advantageous exchange lead to optimal social outcomes.

Despite the virtue of the price system for making decision (on the production and consumption of goods), the price system does not always work, nor is it always desirable to rely on it. *Market failure* is thus a situation in which the allocation of goods and services are not efficient. Prices often understate the full range of services provided by an asset or simply do not exist to send a signal about the value of the asset. Market failure occurs when the private decisions based on such prices, or in their lack, do not generate an efficient allocation of resources. Inefficiency, in this sense, implies that the resources could be reallocated to make at least one person better-off without making any one else worse-off.

On the consumption side, *Market failure* usually involve goods that have characteristics of *'publicness'* or involve externalities. Such public goods are defined to have two fundamental characteristics viz. excludability and rivalry. While 'excludability' has to do with whether it is *possible* to use prices to ration the selective use of the good, 'rivalry' has to do with whether it is *desirable* to ration such selective use through prices or any other means. Environmental quality and ecological services, like many other public goods, are not exchanged in markets because of the problem of market failure in the sense of fixing a due price for it i.e. the price do not communicate society's desires and constraints to protect the environment accurately. Some markets can fail due to the nature of the goods being exchanged having the attributes of *non excludability*. This can cause under-investment because developers cannot see much benefit to make the development effort worthwhile. This can also lead to resource depletion in the case of common-pool resources, where, because the use of the resource is *rival* but non-excludable, there is no incentive for users to conserve the resource. An example of this is a lake with a natural supply of fish: if people catch the fish faster than they can reproduce, then the fish population will dwindle until there are no fish left for future generations.

Consider an important ecological service like biodiversity which has manifold tangible and intangible benefits. However, the threat to biodiversity exist because many of the services are non-rival and non-excludable. As a result, biodiversity by itself has no value reflected in market prices. In contrast, the commodity resources of the habitat (e.g. minerals, timber, non-timber products, chemicals, game, etc.) are valued in the market, and their supply and demand reflect the relative scarcity of these goods. There is thus a pressure to harvest these commodity goods at the expense of biodiversity. This lack of complete market (or incomplete market) implies that the unintended effects of private economic decisions can create biodiversity loss to a socially inefficient level.

Climate change is the greatest market failure the world has ever seen and it interacts with other market imperfections. To arrest this, three elements of policy are required for an effective global response. The first is the pricing of carbon, implemented through tax, trading or regulation. The second is policy to support innovation and the deployment of low-carbon technologies. And the third is action to remove barriers to energy efficiency, and to inform, educate and persuade individuals about what they can do to respond to climate change.

Theoretically, the ideal benchmark for an efficient allocation of resources is the perfectly competitive market, where private decisions lead to social optimum. Given this, we can explore how the perfect market benchmark misfires to specifically lead to violation of ideal conditions leading to market failure. These are stated in terms of: (i) non-exclusion; (ii) non-rival consumption; (iii) incomplete market; (iv) externalities; (v) non-convexities; (vi) asymmetric information; and (vii) public goods/bads. One important form of market failure, not considered here, relates to non-competitive behaviour such as monopoly power, as it is not generally associated with environmental assets.

2.3.1 Non-Excludability

Attaching a price to the consumption of a good or bad means that we must be able to deny that good for consumption if the price is not paid. Generally, we would expect to see exclusion only when the benefit of exclusion outweighs the cost of exclusion. In view of this, change in the cost of exclusion and technology over time plays a major role in determining exclusion. For instance, consider the case of household production of garbage (a bad as it needs to be disposed of in an environmentally friendly manner) which is excludable only with the right laws on littering and trespass. But urban air pollution is not excludable as everyone consumes it to the same degree. In general, therefore, "a *'good'* is excludable if it is feasible and practical to selectively allow consumers to consume the good. Likewise, a *'bad'* is excludable if it is feasible and practical to selectively allow consumers to avoid the consumption of the bad".

2.3.2 Non-Rivalry

'Air pollution' and the 'global climate change' (threatened by green house gases) are examples of non-rival goods as one person's experience of the deteriorating effects of these is equally experienced by all others i.e. one person's experience of the change will not impinge on others from experiencing the same. On the other hand, the standard household garbage is an example of rival bad as someone's consumption of it, makes it unavailable for others to consume. In general, therefore, "a bad (or a good) is rival if one person's consumption of a unit of the bad (good) diminishes the amount of the bad (good) available for others to consume i.e. there is a negative (positive) social opportunity cost to others associated with consumption".

One complicating factor that applies to common goods like a road is 'congestion'. A sparsely populated rural highway is non-rival in that there is no opportunity cost associated with one additional person using the road. However, once the congestion sets-in, there is opportunity cost for an additional driver with the road no longer being non-rival. Roads, by their nature of indivisibility in production, can handle some amount of traffic without being congested. Rivalry is thus important as the key is 'efficiency'. If there is no cost associated with the incremental use and the price equals marginal cost, the incentive to invest and produce is itself eliminated.

2.3.3 Externality

Externality is said to exist, if the consumption or production activity of an individual or firm affects another person's utility or firm's production for which no compensation is made (i.e. where the condition of Pareto optimal resource allocation is violated). If external costs exist (such as in environmental pollution where the victims are not compensated), more of the same might be produced than if the producer were to compensate for such external damages to the victims. For the purpose of such assessments, the overall cost and benefit to society is defined as the sum of the imputed monetary value of benefits and costs to all parties involved. Thus, unregulated markets in goods or services with significant externalities generate prices that do not reflect the full social cost or benefit of their transactions. Such markets are therefore inefficient and become instances of market failure.

A good or service could also have significant externalities where gains or losses associated with the product (or its production or consumption) differs from the private cost. Such externalities can be innate to the methods of production or other conditions important to the market. For instance, a firm producing steel pays for the resources (inputs) used at the prevailing market price with the costs incurred reflected in the final market price of steel. If the firm also pollutes the atmosphere when making steel, and is not made to pay for pollution abetment cost, then such a cost will have to be borne by the society. Hence, the market price for steel will fail to incorporate the full opportunity cost to society of its production. In this case, the market equilibrium will not be optimal. More steel will be produced than would be the case when firms are made to pay for such damages. Consequently, the marginal social cost of the later units produced would exceed the marginal social benefit. An external cost thus exist when the following two conditions prevail: (i) an activity by one agent causes a loss of welfare to another agent; (ii) the loss of welfare is uncompensated. If the loss of welfare is accompanied by a compensation by the agent causing the externality, the effect is said to be *internalised*.

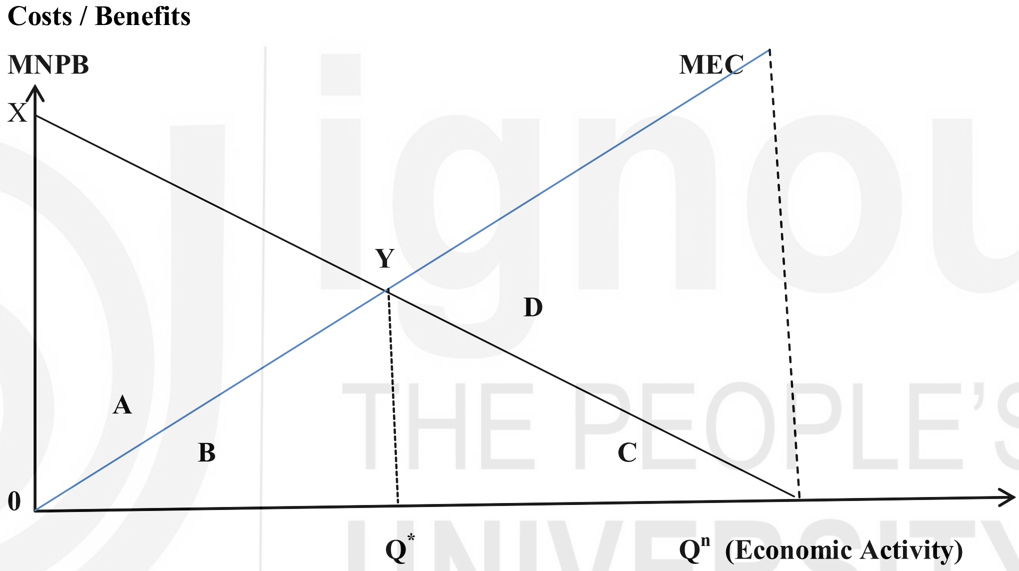

Figure 2.2: Economic Definition of Optimal Pollution

Pareto Optimality: Although the ultimate interest might be eliminating pollution, the laws of thermodynamics convey that there can be no such thing as non polluting product as to achieve zero pollution we should have zero economic activity. Further, the physical presence of pollution does not mean that economic pollution exists. Moreover, even if economic pollution exists we may not need to eliminate it unless it is in excess of the nature's absorption capacity. Thus, corresponding to an optimum level of economic activity, Q*, the optimal amount of economic damage (i.e. the optimum level of externality) is defined as the point at which the 'marginal net private benefit' is equal to the 'marginal external cost' i.e. MNPB =MEC i.e. the area B = OYQ* (Figure 2.2). Thus, OYQ* (the point of equality of MNPB and MEC) is the point at which the price equals the marginal social cost (MSC). Hence:

MNPB = MEC = P – MC (where MC is the marginal cost of producing the polluting product).

Thus, P – MC = MEC

Or, P = MEC + MC = MSC

Therefore, price equal to the marginal social cost (MSC) is the condition for Pareto optimality.

2.3.4 Incomplete Market

Market failure with environmental assets is generally linked to incomplete markets. Markets are incomplete because of the failure or inability of the institutions to establish well defined property rights – the phrase used to indicate the right to use a resource. In case of environment, lack of well defined property rights for clean air makes it difficult for the market to be complete. Thus, people who live downwind from a coal fired power plant suffer from the pollution effect but cannot halt the harm the plant does to their health unless the right to claim a compensation from the operator of the upwind plant exist. With incomplete market of undefined rights, the operator lacks an economic incentive to control emission by switching over to less polluting practices. This inability of the government to assign rights so that markets are complete provides the rationale for government to intervene for the management of environmental resources. A solution to this situation, provided by Coase (1960), is explained later in Section 2.4.

2.3.5 Non-Convexities

If markets are complete, it will send the right signal about the socially optimal level of pollution. But for many physical systems, the marginal benefit and cost are not well behaved. Thus, marginal cost may at first increase with increased pollution, but may subsequently decrease. This is referred to as non-convexity implying that there may be more than one locally optimal level of pollution. This is opposite to a complete market situation where the equilibrium level of pollution not only exists but is also unique.

2.3.6 Asymmetric Information

Markets are generally incomplete due to information asymmetry – a situation where full information about the agents and their action are not completely known to all players involved in a market transaction. In such cases, two types of problems, referred to as *moral hazard* and *adverse selection* arise. In the case of moral hazard, markets are 'confounded' due to the *hidden actions* of an agent in a manner unobserved by the other. The adverse selection problem, on the other hand, 'depresses' the markets because an agent cannot again observe a '*hidden quality*' of goods or services. Both the tactics (hidden actions and hidden quality) retard the operation of market constraining the efficient use of resources.

Moral hazard implies that a regulator cannot well monitor pollution abatement. The firm has thereby an incentive to shirk the control costs in return for some benefits. The outcome implies more pollution relative to the economically efficient level. Moral hazard can also lead to an inefficient *pooling* of environmental risks. However, environmental risks being unavoidable, it is better to find a market where those who are less willing to bear the risk could sell the risk to those who are willing to buy it. Given that accidental spills or storage of pollution can create potential financial liabilities (e.g., clean up costs, medical expenses), a firm would like to pay to pass these risks on to an agent such as an insurer. But since there is a trade-off between risk-bearing and incentives, the market for pollution liability insurance will be incomplete. As a result, the market will end up producing an inefficient allocation of risk.

Adverse selection too affects environment. The policy of sustainable production in an eco-friendly manner requires the adoption of methods of production which are more expensive. If the buyers are not convinced of the sustainability standards of the product, they have no incentive to pay the price premium. If buyers with greater willingness to pay disappear, the sellers too disappear and the market collapses. Preventing such collapse require a voluntary or government sponsored certification scheme.

2.3.7 Public Goods and Bads

The characteristics of a commodity being a public good or bad can be a reason for market failure. A public good is a special form of externality distinct from private good with its non-excludable and non-rival characteristics. Here, a distinction is made between *pure* and *impure public goods*. A pure public good is both non-rival and non-excludable. An impure public good, on the other hand, might be either non-excludable or non-rival, but not both. Climate change protection, ozone layer and biodiversity are examples of pure public good in which the benefits accrue to all those across the globe. Common property and club goods like rivers, local parks, lakes are impure public goods because the benefits are excluded from the non-members of the group who own the resource. Of these, climate change protection is the most obvious form of environmental public good since no nation can be excluded from the emission reduction effort of another nation. Likewise, biodiversity preservation is another example of public good as no person can be excluded from the benefits created by a stable ecosystem created by preserving the different species. If people derive value simply from the existence of a species, its exclusion is impossible. This holds for many environmental resources. Figure 2.3 illustrates common situations where the two criteria of rivalry and excludability are jointly and separately applied.

	Excludable	Non-Excludable
Rival	**Private Goods** Household garbage	**Common Goods** (common-pool resources like village grazing land) Household garbage in medieval ages, fish stocks, timber, coal
Non-Rival	**Club Goods** Water pollution in small lake, indoor pollution in private parks, satellite television	**Pure Public goods** Noise, greenhouse gases

Figure 2.3: Distinction Between Pure and Impure Public Goods

The relevance of these properties for the socially optimal provision of public goods, avoiding a situation of market failure, is the potential problem of '*free riding*' arising out of the non-excludability property. Each person, therefore, has an incentive to let someone else provide the public good thereby demonstrating the incentive to free-ride off the efforts of others.

Check Your Progress 2 [answer the questions in about 100 words in the space given]

1) Why are markets important? In what does the power of a perfectly functioning market lie?

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2) What are the three actions required to arrest the climate change effect?

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3) In what circumstance a good (or a bad) can be made 'excludable'? Which two factors are important in determining exclusion?

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4) Give examples of 'non-rival' goods and a 'rival bad'. What is their link to 'social opportunity cost'?

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5) Why does a polluting firm continue to do so in the absence of an institutional system to act as a disincentive? When is a negative externality said to be internalised?

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6) Is it always desired to curb pollution? Why? Under what conditions can Pareto Optimality be achieved?

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7) Illustrate how incomplete markets for protection of environment could lead to market failure.

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8) What is non-convexity? How is it different from a complete market situation?

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9) What are the two problems that arise due to 'information asymmetry'? What are their consequences to controlling their environmental risks?

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10) Distinguish between pure and impure public good. Give examples of both.

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2.4 PROPERTY RIGHTS VERSUS COMMON PROPERTY

Environmental pollution is a form of market failure, usually because of over exploitation of resources with common property ownership or with open access. In this context, it is argued that in an economy with well defined and transferrable property rights: (i) individuals and firms have every incentive to use natural resources as efficiently as possible; and (ii) markets and prices emerge from collective economic behaviour provided application of exclusion principle is possible. Property rights are thus crucial to give rise to a successful market system. A well defined property right system has thus the following four characteristics:

- *Comprehensive* – All resources are either privately or collectively owned and all entitlements are defined, well known and enforced.
- *Exclusive* – All benefits and costs from use of a resource should accrue to the owner, and only to the owner, either directly or by sale to others. This applies to both private and common property resources.
- *Transferable* – Property rights should be transferrable from one owner to another through a voluntary exchange. The owner thus has incentive to conserve the resources beyond the time he or she expects to make use of it.
- *Secure* – Property rights to resources should be secure from involuntary seizure or encroachment by other people, firms, and the government. Security provides the owner with the incentives to improve and preserve a resource while it is in his or her control rather than exploit the assets.

A common-pool resource, also called a common property resource (CPR), is a type of good consisting of natural or human-made resource system (e.g. an irrigation system or fishing grounds), whose size or characteristics makes it costly (but not impossible), to exclude potential beneficiaries from its use. Unlike pure public goods, due to rivalry, common pool resources face problems of congestion or overuse. A common-pool resource typically consists of a core resource (e.g. water or fish), which defines the stock variable, while providing a limited quantity of extractable fringe units, which defines the flow variable. While the core resource is to be protected or nurtured in order to allow for its continuous exploitation, the fringe units can be harvested or consumed. Examples of common-pool resources include irrigation systems, fishing grounds, pastures, forests, water or the atmosphere. A pasture, for instance, allows for a certain amount of grazing to occur each year without the core resource being harmed. In case of excessive grazing, the pasture may become more prone to erosion and eventually yield less benefit to its users. Because their core resources are vulnerable, common-pool resources are generally subject to the problems of free-riding leading to congestion, overuse, pollution, and potential destruction unless harvesting or use limits are devised and enforced. Free-riding can lead to what is commonly called the classic case of the prisoner's dilemma, also called *tragedy of the commons* (dealt with it in detail in Unit 15). The dilemma exists when people find that their individual incentives lead them to the worst outcome possible – both for themselves and the society.

Common property regimes (or systems of management) arise when users acting independently threaten the total net benefit from the common-pool resource. In order to maintain the resource system, such regimes coordinate their strategies to keep the resource as a common property instead of dividing it up into bits of private property. Common property regimes typically protect the core resource and allocate the fringe resources through community norms of consensus decision-making. Common resource management has to face the difficult task of devising rules that limit the amount, timing, and technology used to withdraw the fringe resource units from the resource system. Setting the limits too high would lead to overuse and eventually to the destruction of the core resource while setting the limits too low would unnecessarily reduce the benefits obtained by the users.

In the common property regimes, the resources are not public goods and access to the resource is not free. There is relatively free but monitored access to the resource system for community members with mechanisms in place to allow the community to exclude outsiders from using its use. Thus, a common-pool resource appears as a private good to an outsider and as a common good to an insider of the community. The resource units withdrawn from the system are typically owned individually by the appropriators. A common property good is rivalled in consumption.

Analysing the design of long-enduring CPR institutions, Elinor Ostrom identified eight 'principles of design' which are prerequisites for a stable CPR arrangement. These are: (i) clearly defined boundaries; (ii) congruence between appropriation and provision rules suitable to local conditions; (iii) collective-choice arrangements allowing for the participation of most of the appropriators in the decision making process; (iv) effective monitoring by monitors who are part of or accountable to the appropriators; (v) graduated sanctions for appropriators who do not respect community rules; (vi) conflict-resolution mechanisms which are cheap and easy to access; (vii) minimal recognition of rights to organize; and (viii) in case of large CPRs allowing for formation of organisations in the form of multiple layers of nested enterprises, with small, local CPRs as their bases.

Common property regimes typically function at a local level to prevent the over exploitation of a resource system from which fringe units can be extracted. In some cases, government regulations combined with *tradable environmental allowances* (TEAs) are successfully used to prevent exploitation. In other cases, however, excessive use or pollution continue.

2.4.1 Coase Theorem

Statement: Assume a world in which some producers or consumers are subject to externalities generated by other producers or consumers. Further assume (1) everyone has perfect information, (2) consumers and producers are price takers, (3) there is a costless court system for enforcing agreements, (4) producers maximise profits and consumers maximise utility, (5) there is no income or wealth effect and (6) there is no transaction cost. In this case, the initial assignment of property rights, regarding the externalities, does not matter for efficiency. If any of these conditions does not hold, the initial assignments of right does matter.

Suppose there are two agents, a polluter and a victim, located in the upstream and downstream of a river who disagree about the optimal level of pollution. The polluter is engaged in some polluting production process, discharging the untreated polluted water to the river. The victim who is located in the downstream of the river, is also engaged in some production activity but gets severely affected by the polluted water. While both have the right to the water flown through the river, the emission of the polluter reduces the return to the victim. Figure 2.4 (similar to fig 2.3) shows the level of polluter's activity, Q, on the horizontal axis and costs and benefits in money terms on the vertical axis. The marginal external cost (MEC) to the victim from the pollution, is the value of the extra damage done by pollution from the activity Q.

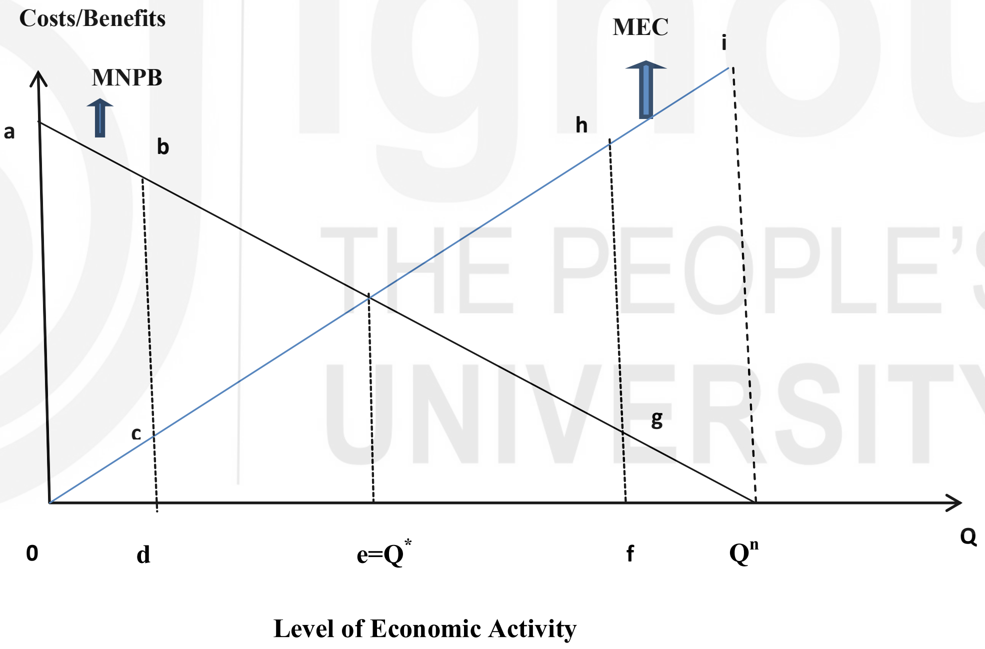

Figure 2.4: Economic Definition of Optimal Pollution

The 'marginal net private benefit' (MNPB) to the polluter from pollution is shown here as rising with Q. The polluter will incur costs (C) in his activity and receive benefits in the form of revenue (Price: P). The difference between the revenue and costs is the 'net private benefit'. MNPB is thus the marginal version of the net private benefit i.e. MNPB = P – MC, which is the extra net benefit from increasing the production activity by one unit. It is shown as falling with Q. Thus, the area under MNPB is the polluter's total net private benefit and the area under MEC is the victim's total external costs. Thus, socially optimal level of pollution is at the level of production Q^*, where MNPB equals MEC. But the market being incomplete, there is no opportunity for the agents to trade for alternative levels of water quality, even though both of them could be better off with trade.

The Coase theorem works on the merits of providing the bargaining power to the victim by extending his rights and then examining the alternatives beneficial to the parties involved. Again, in a two party polluter-victim context, suppose a neutral third party creates a legal bargaining framework by assigning the property rights to clean water to the victim. If the victim prefers zero pollution (i.e. by laying claim to the cleanest water at its source i.e. the origin 'O' in Figure 2.4), it would imply zero level of production for the polluter. Since this is not advantageous to both the parties, there is scope for bargaining. If the issue is whether to move to point 'd' from 'O', the polluter would gain **Oabd** in total profit, but the victim would lose **Ocd**. But since **Oabd** is greater than the **Ocd**, the polluter has the incentive to compensate the victim by an amount greater than **Ocd** and less than **Oabd** and still retain some positive profit. Although the victim is losing **Ocd**, he is also better off as he would gain by compensation. Under this bargaining the move to d is, therefore, Pareto improvement since at least one party is better off and no party is worse off. But if the move from O is towards Q^*, any move to the right of Q^* would make the polluter's net gain become less than the victim's. Hence the polluter cannot compensate the victim to move beyond Q^*. Thus, if the property right belongs to the victim, and if we start at O, there is a natural tendency to move to Q^* which is the social optimum.

Now consider the property right belongs to the polluter. If he chooses the point Q^n (the highest beneficial point to the producer), both the parties have the option to bargain over the pollution. Consider the move from Q^n back to f. Here, the victim can compensate the polluter to give up a certain amount of activity. Since the victim would have to face the maximum loss of **fhiQ**^{n}, if the move to f does not take place, he will be willing to accept less, and the polluter will be willing to offer any amount greater than **fgQ**^{n}. The potential for bargain again exists and further movement towards Q^* might result. Hence Q^* might again be the level of activity to which the system could gravitate.

In the presence of well defined property rights, so long as the scope for bargaining exists between the polluter and the victim, on the basis of above argument, the market will take us to Q^*, which is the social optimum. Thus, regardless of who holds the property rights, there is a clear scope to approach the social optimum. This finding, known as the Coase bargaining theorem, suggests that there is no need for government for controlling the externality, if suitable bargaining power by a framework of property rights is established to enable the market to correct itself.

2.4.2 Limitations of Coase Theorem

Recall that MNPB is defined as :

MNPB = P – MC

and the socially optimal level of pollution occurs where,

MNPB = MEC.

Thus, the above two equations entail:

P = MC + MEC = MSC

Under competitive situation, it is assumed that the MNPB is the polluter's bargaining curve. However, if perfect competition does not prevail, then (P – MC) is no longer the bargaining curve, because it is no longer equal to MNPB. If the polluter is a firm, it should be fairly evident that his bargaining curve is his 'marginal profit curve' and, under imperfect competition, this is equal to 'marginal revenue' minus 'marginal costs' i.e. MNPB = MR – MC. Under imperfect competition, MR is not equal to P because the demand curve is above the marginal revenue curve. It thus follows that the bargaining solution does not apply under imperfect competition. The existence of imperfect competition provides the basis for a serious critique of the Coase theorem.

The assumption of two bargainers with zero transaction costs implies that an efficient agreement will be reached before the two agents are left with no more incentives to bargain and they quit bargaining. But this framework is unlikely to be extended in a multi-party bargaining scenario since the large number of parties will make bargaining costly and complex. Moreover, the zero transaction cost is a hypothetical situation, difficult to match in reality. Such transaction costs include those of bringing the parties together, identifying often widely distributed and difficult to identify sufferers, organising the actual bargaining itself, etc. If the transaction costs are high, so that any one party's share of it outweighs the expected benefit of bargain, that party might withdraw from bargain, or not even agree to come forward. Further, the transaction costs would fall on the party that does not have the property rights.

Letting T = transaction costs, B = gains from the bargain for the party bearing the transaction costs, G = costs of government intervention, there are three possibilities:

- If $T < B$, a bargain might take place.
- If $T > B$, a bargain will not occur, but some other regulatory approach might work.
- If $T > G > B$, government regulation is likely to occur, and it will be efficient.

Income effect

Another important clause in the Coase Theorem concerns the wealth effect. If I am endowed with a right that has value, I am richer. If I do not have that right, I am poorer. We know that demand for goods depends on our income. Consequently, the existence of wealth effect would generate differences in the final bargain. This is the reason for condition (5) in the statement of Coase Theorem.

Identifying the bargaining parties

Even if transaction costs are less than the benefits to be obtained from a bargain, no bargain may take place. Many pollutants are long lived – they stay in the environment for a long period of time and may affect people, years or decades later. Toxic chemicals, radio active wastes, ozone layer depletion and global carbon dioxide pollution are some examples of this category. If bargaining has to exist, then some groups of the present generation would have to bargain on behalf of the future generations, which is more unlikely to happen.

A further problem of identifying the polluters and sufferers arise in case of open access resources. In such cases, it is not clear who will bargain with whom, since no one individual has an incentive to reduce his or her access to the resource. In some other situations, it is difficult to say who the polluters and sufferers are. Sufferers may be unaware of the source of pollution from which they suffer, or even be unaware that damage is being done. The cost of generating the information for the sufferers need to be added to the costs of transacting any bargain. The likelihood of bargain being socially efficient, even if it occurred, is remote given the need to identify the damage done and its distribution among sufferers.

Check Your Progress 3 [answer the questions in about 100 words in the space given]

1) On what grounds, the presence of well defined property rights is expected to prevent cases of market failure in environmental issues?

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2) What are the four characteristics of a well defined property right system?

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3) Define 'common property resource' (CPR) with examples. In what way CPRs are different from public goods?

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4) State the essential pre-requisites identified by Elinor Ostrom as 'principles of design' in a stable CPR arrangement.

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5) Under what conditions the results of 'Coase Theorem' hold? How does the result of the theorem, if holds true, eliminates the need for government intervention?

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6) Does Coase theorem apply under conditions of imperfect competition? Why?

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7) For what reasons, Coase's result is unlikely to work when the assumption of 'zero transaction cost' is violated?

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8) Why is the assumption on 'no difference in the income of the two bargaining parties' essential for Coase's result to work?

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2.5 FUTURE TIME PREFERENCE AND DISCOUNT RATE

Due to the problem of externality and market failure, there is a wide divergence between social and private cost/benefits. Therefore, while making the cost benefits analysis (CBA) of policies designed to improve environmental quality and ecological services, imputation of shadow prices by applying 'non-market' valuation techniques are required. Since most of the goods and services have depletable stock values, the benefits or costs usually spread over a certain time horizon. This requires conversion of all the monetary values (of costs and benefits) into *present value* (PV) terms through discounting.

2.5.1 Potential Pareto Improvement (PPI) Criterion and Cost Benefit Analysis (CBA)

Whether a project/policy improves social welfare in general (i.e. whether at least one person is made better off without making anyone worse off) is often a critical question answered by economists on the basis of 'cost benefit analysis' (CBA). In practice, it is hard to find a resource reallocation that does not impose costs on anyone. In order to overcome this complication, the principle of Potential Pareto Improvement (PPI) criterion (proposed by John Hicks and Nicholas Kaldor) is widely adopted. The principle involves asking the questions: (i) could the gainers compensate the losers and be still better off?; and (ii) are the aggregate benefits larger than the aggregate costs? By measuring the monetary value of benefits and losses, the PPI criterion expresses the money value of the total net benefits of project/policy in terms of a single number. If the net present value is positive, then the resultant resource allocation is taken to be economically efficient since it fulfils both the PPI criterion and therefore the CBA test. However, such an analysis does not say anything about the fairness of resource allocation nor its political acceptability and whether it improves the sustainability of the economy. In spite of this limitation, CBA has turned to be an useful tool because: (i) it addresses an important social concern (the efficiency of resource allocation) and is applicable in a wide range of circumstances; (ii) a wide variety of impacts can be included and compared in the same measurement units; (iii) it can be used in both project and policy appraisal, and as a devise for allocating scarce public money across competing uses; (iv) it possesses an advantage over referendums, since it takes into account both the direction and intensity of preference; and (v) it allows us to emphasize both the economic value of environmental protection as well as the opportunity cost of protecting the environment.

One important feature of CBA is that, like the PPI, all relevant effects are expressed in monetary values so that they can be aggregated. The general principle of monetary valuation in CBA is to value the impact in terms of their marginal social costs (MSC) or marginal social benefits (MSB). In the absence of externality both MSB and MSC can be calculated from the equilibrium market price. However, in the presence of externality generating some external cost, the MSC should be greater than the market price. This is called the shadow price which are estimates of marginal social costs/benefits when market prices are distorted either through externalities or due to government intervention in the market.

2.5.2 Discounting of Cost and Benefit Flows

Welfare economics works on the assumption that individuals have a higher 'time preference' for the present than for the future i.e. people prefer to increase their 'utility' (welfare) sooner rather than later. Hence, it is necessary to convert all the monetary values of costs and benefits into *present value* (PV) terms. In other words, the 'present value' (PV) increases or decreases depending on how soon they will happen. In order to take this factor into account, CBA adopts the practice of *discounting* (i.e. devaluing the future benefits and costs so as to represent their present value). A decision on whether a project or intervention should proceed, is taken when the present value of benefit outweighs the present value of costs. The extent to which future cash flows are devalued is determined through the 'discount rate'. The degree to which we prefer the present benefits over the future benefits is known as the *revealed time preference* ('revealed' in the sense it is reflected in our savings and investment decisions even if it is never articulated). On the other hand, how much an investment pays relative to other uses of the same resource is known as its *opportunity cost*. Together, the concepts of 'revealed time preference' and 'opportunity costs' lead us to the concept of 'discount rate' used to measure the value of future benefits. It is the amount by which a benefit declines in value each year into the future. In financial transactions, the discount rate (δ) is typically set somewhere around the prevailing market interest rates.

Thus, the time effect is taken into account when all costs and benefits are discounted using a discount rate. The present value of cost or benefit [PV (X)] received in time t is calculated as follows :

$PV(X_t)\,[(1+\delta)^t] = X_t$ or

$PV(X_t) = X_t[(1+\delta)^{-t}]$.

The expression $(1+\delta)^{-t}$ or $\frac{1}{[(1+\delta)^t]}$ is known as the discount factor, having the property of always lying between 0 and +1. The further away in time the cost or benefit occurs, the higher the value of 't' and lower the discount factor. The higher the discount rate δ for a given t, the lower the discount factor (since the higher discount rate means a greater preference for things now rather than later).

The debate about discounting the future in public investment is accentuated by environmental problems like biodiversity loss, ecosystem disruption and climate change. All these problems are bound to have long-term impacts which will affect us as well as future generations. Hence, there is a concern for intergenerational equity. Thus, how much should our current generation invest? Should we sacrifice a part of our well-being for the benefit of future generations? This is dependent, among other things, on the inter-temporal preferences (and thus discounting of public investment) of the current generation. If we discount the investments in biodiversity conservation and climate change mitigation, the benefits of our investments for future generations will appear smaller in present value terms. This would foster a state of 'low inter-generational equity' where the wellbeing of different generations (including those yet to be born) would be unequally valued. In this context, the concept of **Social Discount Rate** reflects a society's relative valuation on today's well-being projected into the future. The appropriate selection of a social discount rate is crucial for cost-benefit analysis since it has important implications for resource allocations. There is wide diversity in social discount rates with the developed nations typically applying a lower rate than the developing nations.

A higher Social Discount Rate (SDR) reduces the prospects of funding of a social project since it implies greater risks to the assumption that the benefits of the project will be reaped. A small increase in the social discount rate can matter enormously for benefits far into the future and hence it is very important to be as accurate as possible when choosing which rate to use. There is a strong case made for factoring-in the equity issue when discounting the costs and benefits of intergenerational projects such as those designed to combat climate change and environmental degradation. In case of a CBA for a private investment, discounting can be set relatively high depending on various factors and the time preferences of the entrepreneurs in question.

There are a number of qualitative differences between social and private discount rates (SDR and PDR) and the evaluation of projects associated with them. The governance of social project funding is different because estimating the benefits of social projects requires the making of ethical choices about the benefits to the society at large. Thus, choices about the SDR of environmental protection projects, such as funding the reduction of global warming, places a greater valuation on future generations. Two contrasting views on these issues are therefore salient:

On the one hand, many mainstream economists consider that what is valid for individuals (i.e. relatively strong preference for the present) is also valid for society as a whole. According to this view, the 'social discount rates' (i.e. discounting used for appraising public investment) should not only be used but also be based on individual preferences (i.e. collective preferences perceived as the aggregation of individual/private preferences). This view thus takes an empirical rather than normative stance.

On the other hand, many other economists think that the question of discounting public investment is an essentially philosophical one, relating to how much a society should value the future generations relative to the present. According to this stream of thought, social discount rates cannot be based on the evidently high 'time preferences' of individuals and should be set sensibly lower. In practice, discount rates for social projects and public interventions are set differently in different countries. Despite the debate outlined above, many countries opt to set their public discount rates lower than private discount rates. Aside from the general lack of consensus on the matter, discounting the future has critical implications particularly for environmental sustainability.

2.5.3 Importance of Discount Rate for Global Climate Change

Since there is a strong probability that the world will suffer significantly in the future due to global change in temperature, finding the correct social discount rate for the benefits of reducing CO_2 emissions and other harmful greenhouse gases is very important. The choice of an appropriate social discount rate has long been debated with many economists arguing that giving future generations less weight than the current generation is 'ethically indefensible.'

Greenhouse gases emitted today affect global temperatures in 50 years or so, just as we are experiencing temperature rise caused by emissions 50 years ago. There is thus a substantial time lag between causes and effects. This time lag complicates the efforts to do something about the problem, as people are not generally inclined to sacrifice now to gain benefits (or to avoid costs) 50 years down the road. The policy challenge is to, therefore, extract those damages from the future to the present. The preferred way to achieve this goal is to put a price on carbon via a tax or a cap. This is meant to reflect the damages the carbon emissions will cause in the future i.e. to internalise the externalities. To figure out the 'right' price for a ton of CO_2 emissions two questions need answering: (i) how much damage will a ton of carbon do? and (ii) how much is it worth to avoid that amount of damage?

Climate science can help in generating an approximate figure to the first question. But to answer the second question i.e. how much future climate mitigation is worth today — what's called as the *social cost of carbon* — the 'discount rate' needs to be decided. Using a widely ranged discount rate of 0.1 percent (by Nicholas Stern) and 3 percent (by William Nordhaus) the estimates of social cost of carbon made in today's prices range from as high as $85 a ton to a relative low of $10 a ton respectively. One of their primary assumptions is that people in the future will be richer and thus better prepared to deal with climate damages. The Stern Review (on the Economics of Climate Change) argues for almost zero discrimination of future generations. U.K. economist Nicholas Stern, in his famed Stern Review, used largely the same scientific data as Nordhaus, but with a discount rate of just 0.1 percent. Not surprisingly, Stern's modelling suggests that the social cost of carbon is closer to $85 a ton and rising. Thus, two critical questions are: (i) what should be the discount rate?; and (ii) how do we decide on it?

Check Your Progress 4 [answer the questions in about 100 words in the space given]

1) What are the common limitations of the PPI criterion and the CBA test? In spite of these limitations, for what reasons is the CBA still considered useful?

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2) What is a 'shadow price'? When are they used?

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3) How is 'discount rate' useful? State the two concepts that help in arriving at a 'discount rate'?

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4) What does the 'social discount rate' reveal?

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5) In the context of intergenerational climate change, what is meant by 'internalising the externalities'?

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2.6 LET US SUM UP

There is a close relationship between economy and environment. In this, the environmental resources play a critical role in economic growth. However, unless environmental resources are used judiciously, the principle of sustainable development is violated. Against this background, the unit discusses various concepts of market failure and their effect on environment. The importance of property rights in protecting the common resources is explained by a statement and illustrative application of Coase theorem. The concepts of future time preference is explained with a reference to the importance of working out the 'discount rate'.

2.7 KEY WORDS

Biodiversity : Refers to describe the variety of life in the world or in a particular habitat or ecosystem.

Climate Change : A change in global or regional climate patterns, in particular, a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the burning of fossil fuels.

Efficiency : Defined as Pareto optimality – the impossibility of reallocating resources to make one person in the economy better off without making someone else worse off.

Entropy : Amount of energy not available for work.

Externalities : Refers to economic activities causing an adverse impact on a third party but suffer on account of receiving no compensation from either of the parties for the losses suffered. While the adverse situation refers to negative externalities, externalities can be positive too.

Intergenerational Equity : Is a concept which says that humans 'hold the natural and cultural environment of the Earth in common both with other members of the present generation and with other generations, past and future'

Man-made Capital : Wealth, as in money or property, owned, or accumulated by an individual, partnership, or corporation used or available for use in the production of more wealth. This includes all physical infrastructure (buildings, roads, machinery, etc.) used to produce goods and services. Also includes physical manifestation of information, techniques, and knowledge required to produce goods and services.

Non-excludable : A good or a service is non-excludable if it is extremely costly to exclude anyone from consuming the good or service.

Non-rival : A good or a service is non-rival if one person's use does not reduce another's use.

Human Capital : Is the stock of knowledge, habits, social and personality attributes, including creativity, embodied in the ability to perform work so as to produce an economic value.

Market Failure : Are scenarios where individuals' pursuit of pure self-interest leads to the allocation of goods and services that are not efficient and which can be improved upon from the societal point of view.

Open Access Resources : The resources owned by nobody.

Pareto Optimal : Relates to or denotes a distribution of wealth such that any redistribution or other change beneficial to one individual is not detrimental to any one or more of others.

Property Right : Relates to the right to use a resource.

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2.9 ANSWERS/HINTS TO CHECK YOUR PROGRESS QUESTIONS

Check Your Progress 1

1) See 2.2 and answer.

2) See 2.2 and answer.

3) See 2.2 and answer.

4) See 2.3 and answer (Uncertainty, accurate information, *trust* vis-à-vis limited consumer's 'ability' to process information and variability in information received and processed).

5) See 2.4 and answer.

6) See 2.4 and answer.

7) See 2.4.1 and answer.

8) See 2.4.1 and answer.

Check Your Progress 2

1) See 2.3 and answer.

2) See 2.3 and answer.

3) See 2.3.1 and answer.

4) See 2.3.2 and answer.

5) See 2.3.3 and answer.

6) See 2.3.3 and answer.

7) See 2.3.4 and answer.

8) See 2.3.5 and answer.

9) See 2.3.6 and answer.

10) See 2.3.7 and answer.

Check Your Progress 3

1) See 2.4 and answer.
2) See 2.4 and answer.
3) See 2.4 and answer.
4) See 2.4 and answer.
5) See 2.4.1 and answer.
6) See 2.4.1 and answer.
7) See 2.4.2 and answer.
8) See 2.4.2 and answer.

Check Your Progress 4

1) See 2.5.1 and answer.
2) See 2.5.1 and answer.
3) See 2.5.2 and answer.
4) See 2.5.2 and answer.
5) See 2.5.3 and answer.