Indira Gandhi
National Open University
School of Social Sciences

MEC-108
Economics of Social Sector and Environment

Block

5

SUSTAINABLE DEVELOPMENT

UNIT 13

Pillars of Sustainable Development 5

UNIT 14

Green Accounting and Environmental Cost Benefit Analysis 25

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Common Property Resources Management 44

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BLOCK INTRODUCTION

The present block (Block 5) on Sustainable Development (SD) consists of three units. **Unit 13**, on Pillars of Sustainable Development begins by providing a conceptual framework that takes into consideration 'multiple objectives' and 'multi-disciplinarity' nature of developmental outcomes and processes. Presenting an account of the various definitions of sustainable development that have been put forward in the literature over time, the unit proceeds to explain the two basic conceptual approaches to the issue of SD viz. the capital approach and the ecological approach. Distinction between the two concepts of 'weak sustainability' and 'strong sustainability' is then presented. The unit then discusses the various indicators of sustainable development like the CSD indicators, MDG indicators and the SDG indicators. Some aspects of operationalising sustainable development in National context are finally presented through 'national development strategies and practices of sustainable development' adopted in India.

Unit 14 is on Green Accounting and Environmental Cost Benefit Analysis. The 'System of National income Accounts' (SNA) which is for long in practice, giving importance to only marketable and monetised goods and services (and ignoring the consumption and depletion of environmental resources in the process over time), is first explained in the unit. It then highlights the requisite modifications in this conventional approach that needs to be introduced. In this, various methods like Physical Accounting, Pollution Expenditure Accounting, Development of Green Indicators, etc. are explained. Presenting a brief account on the usefulness of environmental accounting, the unit concludes by discussing the issues of 'environmental cost benefit analysis'.

Unit 15 deals with the theme of 'Common Property Resources' (CPRs) and Management challenges. Beginning with an outline of the various characteristics of CPRs, the unit explains in detail the various theoretical issues behind the management of CPRs. The results of some major studies conducted on CPRs in India and the issues relating to the management of Global Commons are then presented. The unit winds up by discussing at length the issues behind Global Environmental Externalities and Climate Change.

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UNIT 13 SUSTAINABLE DEVELOPMENT

Structure

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13.0 OBJECTIVES

After reading this unit, you will be able to:

- highlight the multi-disciplinary character of sustainable development (SD);
- discuss the structural phenomena of SD in terms of its 'non-linearity, resilience and irreversibility' dimensions;
- define the concept of SD as enunciated by the Brundtland Commission and some other major contributors;
- describe the five broad interpretations that flow from the various definitions offered on SD;
- elaborate the major approaches to measuring SD evaluating in the process on their sufficiency to comprehensively deal with its multifarious nature;
- distinguish between the concepts of Hicksian-Sustainability and the Hartwick-Solow-Sustainability;

- critique the two concepts of 'weak and strong sustainability' by bringing out the major differences between them;
- outline the major 'indicators' of sustainable development and the role of National Accounting Framework in providing the 'Aggregate Indicators' of SD; and
- explain the 'application of sustainable development indicators to national development strategies' and 'sustainable development practices in India'.

13.1 INTRODUCTION

The growing population, with expanding demand and consumption, pose concerns regarding the sustainability registered by many countries including India. If the increasing demand must be met by the greater exploitation of available resources, they tend to exert additional pressure on the fixed aggregate resource base of the economy. The natural question which has come to occupy the minds of contemporary policy makers and social thinkers is whether the impressive growth rates of the economy can continue and if so, how? There are various ways to express this concern. One such indicator is 'ecological footprint'. Using this, it is established that the world's present demand on the biosphere is already 25 percent more than the bio-capacity i.e. the biosphere's ability to meet the demand. In case of India, it is estimated that the total 'national footprint' has doubled since 1961. It is also shown that the balance between India's demand on and supply of natural capital has worsened, leaving the country as an ecological debtor. It suggests that the rate of depletion of the country's ecological assets and productive base is more than the rate of its accumulation. These analyses indicate that the current global level of consumption is unsustainable. In order to take the right measures which will ensure a development path that is sustainable to continuing growth of the economy (in the face of rising local and global resource constraints), one has to examine the true implications of the term 'sustainability' and the conditions under which it can be achieved. Although different disciplines of knowledge have defined the concept of sustainability in different ways, the discussion here largely adheres to the meaning and interpretation of sustainability adopted by economists. The vast literature on sustainable development (SD) is summarized in this unit with a focus on the following issues:

- Different interpretations of SD
- Measurement of SD
- SD in practice and corresponding policy challenges.

13.2 CONCEPTUAL FRAMEWORK

The idea of organising an economic system so that it produces an enduring flow of output is not new. Foresters and fishery have long been concerned with sustainable yields i.e. harvesting trees and fish at a rate less than or equal to the natural growth rate of the 'biomass'. Assuming that there is fairly a good knowledge of the dynamic growth curve of the resource in question (i.e. how it grows or depletes over time) it is possible to decide on sustainability practices.

Economies do not rely on renewable resources like fish and trees alone, although many come very close to it. Sustainability, therefore, means that we must make sure that substitute resources are made available before the non-renewable resources become physically scarce. This also means that we must ensure that the environmental impact of using the resources are kept within the potential of Earth's 'carrying capacity' to assimilate the impacts. In this context, it is important to note the multi-disciplinary facets of sustainable development.

13.2.1 Multi-disciplinary Character of Sustainable Development

The concept of SD is essentially an interdisciplinary one. Although the important issue of intergenerational equity was addressed by Solow, much of the terminology of SD did not necessarily arise out of the economic concerns of depletion of environmental resources alone. In other words, the economic approaches were found to be not comprehensive enough to cope with the entire range of issues of sustainable development. In view of this, an appreciation of the behaviour of the ecosystem in general, and its various geophysical systems in particular, are equally important. In light of this, there is a need to examine the *structural phenomena* of the resources consumption process (in the course of economic growth and development) in order to appreciate the importance of evolving different sustainable development measures. The structural phenomena can be specified in terms of nonlinearity, resilience, and irreversibility dimensions of the eco-system's role in aiding the economic development process.

13.2.2 Structural Phenomena

The structural phenomena inherent in the process of SD can be brought out in terms of its three major dimensions viz. non-linearity, irreversibility and resilience.

Non-linearity

Most phenomena on this planet (whether it is growth in the size of a population or accumulation by compound interest principle of capital) obey nonlinear behaviour. Ecological change is neither gradual nor continuous. In particular, while the biological growth depicts a continuing growth relationship over time, the same tend to be rather abrupt when it comes to their decay. Another example of non-linearity is the intake of toxic inputs and its effect on the physical fitness of living beings and organisms.

Further, when environment fluctuate, the mean fitness of 'genotype-W' is usually represented by its geometric mean fitness rather than its arithmetic mean fitness. This is to say, if X_i is the fitness level in each of the N environments, their mean fitness is represented as:

$$W = \sqrt[N]{\prod_{i=1}^{N} X_i} \; .... i = 1, ..., N$$

The implications of non-linear behaviour in ecosystems need to be appreciated to assess the relative merits and demerits of various policies affecting these systems. For instance, (i) periodic and random small changes can propagate the disturbances dramatically and flip the system into another path of its evolution; (ii) regions of stable relationships collapse as slow processes/influences accumulate and move the system from one set of controlling mechanisms and processes to another. Likewise, when forest ecosystems undergo creeping degradation through acid rain, the forests experience slow but steady decline. And while the increase in fossil fuel consumption can be somewhat linear, the atmospheric pollution's response is often not.

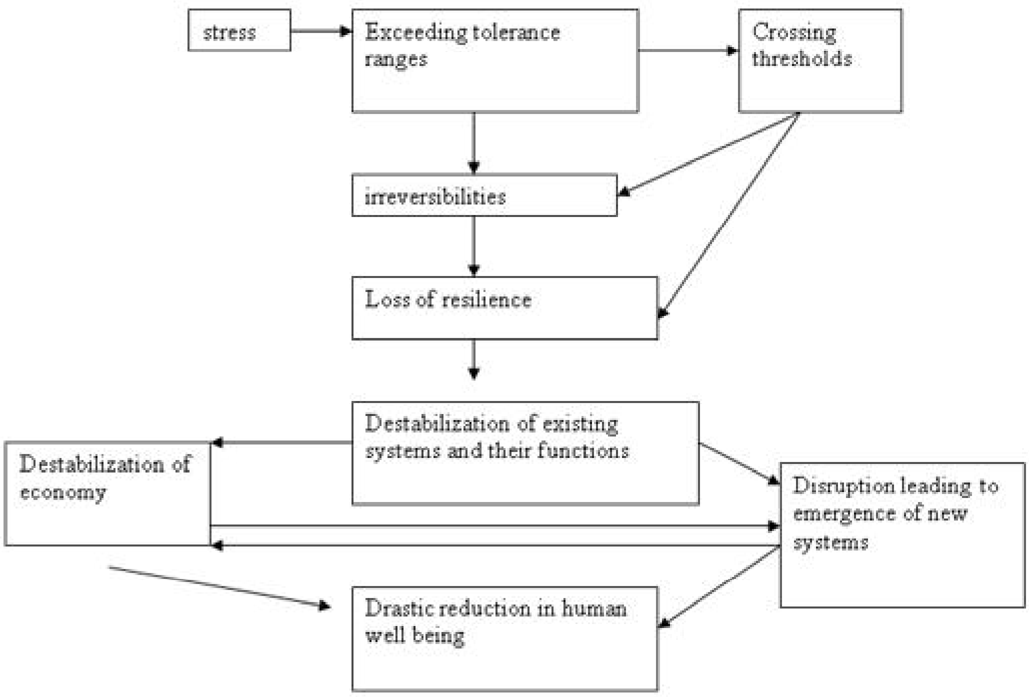
Irreversibility

The cumulative effect of various activities influencing the equilibria of various ecosystems, besides resulting in non-linearities, also leads to irreversibilities (e.g. loss of biodiversity and biological extinction of species). An example is the pollution absorbing capacity of the atmosphere which possesses both the properties of nonlinearity as well as significant irreversibility. Even if the Green House Gases (GHGs) are technically reversible over a period of time, the irreversible damage to the system would have resulted much before the concentration of these GHGs is diffused.

Resilience

Resilience is the buffer capacity or the ability of a system to absorb disturbances, including some components of adaptivity, of the system. Resilience is lost when its range of tolerance for variations in the environmental factors is crossed by the disturbances or external influences. The range of tolerance differs significantly across different species and organisms and a common factor cannot be applied to the entire bio-philia. Loss of resilience tends to shift a system towards its thresholds and eventually leads to its flip from one equilibrium state to another. In a simpler framework, therefore, resilience may be interpreted as the ability of systems or organisms to absorb the disturbances caused. Measured as 'ecosystem resilience', it becomes a useful index of 'environmental sustainability'. If human activities are to be sustainable, ecological systems must remain resilient and any loss of the 'ecosystem resilience' could imply irreversible change in the set of options open to present and future generations.

Figure1: Interdependence of Resilience and Human Welfare



Source: Rao, 2000.

13.3 DEFINITIONS OF SD AND ITS INTERPRETATIONS

In the light of the inter-disciplinary characteristics of the term SD, it is clear that no single definition can comprehensively capture all its characteristics. The wide range of definitions that have emerged in literature, therefore, reflects both the inherent similarities and contradictions of the several interpretations that flow from it. For instance, the Brundtland Commission Report(1987) states that: *SD is that development which* *meets the needs of the present without compromising the ability of future generations to meet their own needs*. It, therefore, underlines the two key essentials as: (i) the particular need to protect the interests of the world's poor; and (ii) the limitations of state of technology and social organizations in preventing the exploitation of environmental resources so as not to affect the needs of future generations. The Commission, therefore, emphasized the overriding priority of attending to the needs of the poor within any society in particular and the world as a whole in general. The rationale for SD, therefore, is to raise the standard of living, especially the standard of living of the most disadvantaged segments in society, taking due care to avoid or minimise uncompensated future costs. Box 1 lists some of the important definitions available in the literature on SD. Five broad interpretations of SD can be inferred from the range of definitions on SD stated therein. These interpretations are helpful to operationalise their inherent essence while implementing them in practice through appropriate policies. These are discussed below.

Box 1: Some Definitions of Sustainable Development

"Sustainability is defined as ... non-declining utility of a representative member of society for millennia into the future". ***Pezzey (1992)***

"Sustainable activity is ... that level of economic activity which leaves the environmental quality level intact, with the policy objective corresponding to this notion being the maximisation of net benefits of economic development, subject to maintaining the services quality of natural resources over time".

Barbier and Markandya (1990)

"Sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs".

World Commission on Environment and Development (WCED,1987)

"The alternative approach to sustainable development is to focus on natural capital assets and suggest that they should not decline through time".

Pearce et al. (1989)

"Sustainable economy ... is one that can be maintained indefinitely into the future in the face of biophysical limits".

Daly (2005)

Source: *Perman et al (1999)*

1. A sustainable state is one in which utility is non-declining over time.

This is the conventional way of interpreting using which Robert M. Solow justified the Rawlsian ethics which defines a society as sustainable if it satisfies the criteria of 'intergenerational equity' (i.e. per-capita utility for all future generations remains constant). Deriving the necessary and sufficient conditions for the constancy of undiscounted utility of per capita consumption over time is, however, a difficult task. Hence, as proposed by John Hartwick, economists have interpreted sustainability as 'constant' consumption over time. More recent literature combines the notion of both constant utility and constant consumption and has come to be known as the '***Solow-Hartwick criterion***'. However, the Solow-Hartwick criterion too is critiqued to ignore the required minimum threshold level of consumption as it does not take into account how large the non-declining initial level of consumption should be. As a compromise, an economy is said to be sustainable if the current consumption standards are the lowest so that they are not allowed to get any worse. This too is considered a perverse interpretation (Perman *et al.*, 1999) motivating other interpretations as follows.

2. A sustainable state is one in which resources are so managed that it maintains production opportunities for the future.

Sustainability is here defined in terms of *maintaining the production and consumption potential* over time. This is in the sense that the productive capacity at any point of time depends mainly on the stock of productive (capital) assets available for use. The word 'capital' used here is integral and is in a very broad sense. It includes all four forms of capital viz. natural (e.g. forests, & fisheries), physical (e.g., plant, equipment), human (e.g. skills, know-how), and intellectual (e.g. disembodied skills, stock of knowledge). Under this interpretation, human-made capital is defined as the sum of physical, human, and intellectual capital. Thus, the productive potential of the entire ecosystem is represented by a simple production function: $Q = f(L, K_N, K_H)$ where Q is the productive potential of the ecosystem, L is labour or human-effort, K_N is stock of natural capital, and K_H is human-made capital. Thus, the productive potential of the economy will be maintained so long as the *composite capital stock is non-declining* over time.

3. A sustainable state is one in which the natural capital stock is non-declining through time.

This interpretation assumes the maintenance of natural capital as a necessary condition for sustaining the economy's productive potential. In other words, considering natural capital as essential for production, it assumes that it is not substitutable by other components of capital. This interpretation too is viewed as limited by the as yet unresolved debate on weak versus strong sustainability (discussed later in Section 13.5).

4. A sustainable state is one in which the resources are so managed as to maintain a sustainable yield of natural resources.

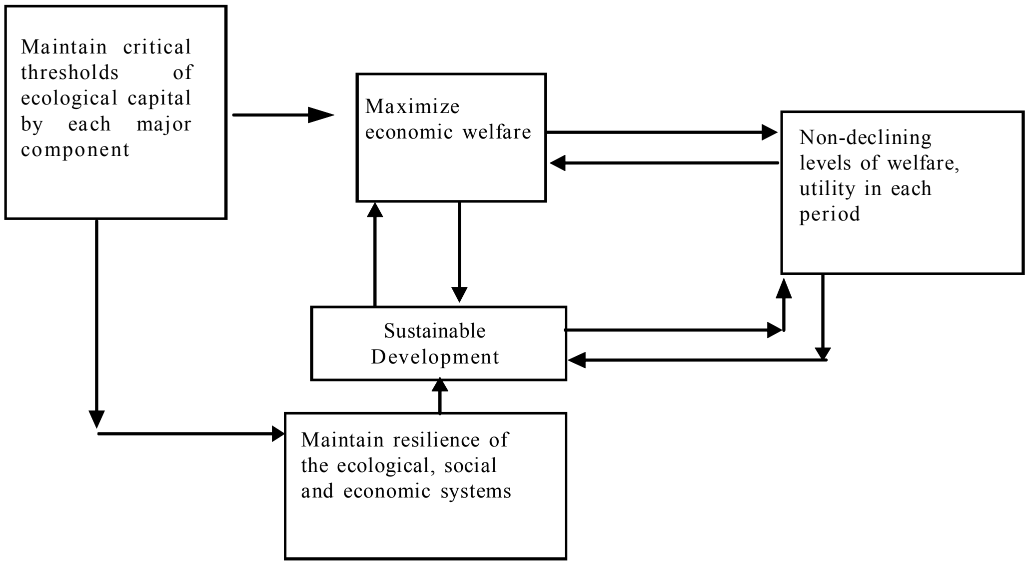
This interpretation of SD is based on the biological or the renewable nature of some natural resource stocks (e.g. forest, fishery). Under this, therefore, a sustainable yield is a steady state in which stocks are maintained at a constant level delivering a constant flow of resource services over time (e.g. timber). This interpretation too carries the limitation of leaving it unexplained whether the stock or flow of such natural resources (to be maintained at a constant level) is a simple or weighted aggregate of different elements constituting the biological eco-system.

5. A sustainable state is one which satisfies the minimum conditions of ecosystem stability and resilience through time.

This interpretation arises from the ecologists' point of view of ecosystem. It defines a system to be ecologically sustainable if it is 'resilient' (Common and Perrings, 1992). The problem with this interpretation is that one cannot know, *ex ante*, if the system would be resilient in the presence of future shocks, but can only be determined *ex post.*

Figure 2 schematically presents the essential linkage between the various elements of each of the above interpretations of the SD concept.

Figure 2: Schematic Representation of Sustainable Development



Source: Rao, 2000.

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

1) Why is it felt that consideration of economic concerns alone is not enough to address the issue of SD comprehensively?

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2) Illustrate the non-linearity behaviour of most phenomena on earth (be it of ecological or economic nature) by an example from real life.

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3) How is 'resilience' defined? Under what circumstances is this lost?

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4) What are the two key essentials of the definition of SD provided by the Brundtland Commission report?

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5) Distinguish between the Hartwick's and the Solow-Hartwick's criterions of defining the SD?

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6) How would you define the productive potential of the eco-system?

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13.4 APPROACHES TO SUSTAINABLE DEVELOPMENT

A widely held view of sustainable development is that it simultaneously refers to the economic, social and environmental needs of the society. According to this view, there must be no independent focus for the sustainability of these three pillars but instead the three pillars (of *economic, social and environmental* systems) must be simultaneously focused for their mutual and complementary sustenance. Satisfying any one of these three sustainability pillars, without satisfying the others, is deemed insufficient for the reasons of: (i) the three pillars are independently crucial; and (ii) each of the three pillars is so essentially interconnected that no time can be lost by debating on which one should be addressed first. In light of this, even the latest System of Environmental-Economic Accounting (SEEA) [which is in many ways an improvement on the conventional system of national income accounts (SNA) – on which you will read more in Unit 14 next], though provides for the compilation of relevant data on the environmental and economic systems, offers relatively little for understanding the social systems. In other words, while the SEEA has a great deal to say about the environmental and economic systems, with regard to the interactions between the three pillars it does not offer much either with respect to the socio-economic interaction or the socio-environmental interaction.

13.4.1 The Capital Approach

The capital approach to sustainable development is associated with the ideas of economists. This is despite the approach going beyond what is typically the domain of economics. It borrows the concept of capital from economics but broadens it in many ways to incorporate more elements that are relevant to the sustainability of human development. In doing so, it takes concepts from other fields integrating them within a framework related to capital. Thus, although one finds a certain amount of disagreement among economists regarding the alternative approaches to sustainable development, substantial agreement nevertheless exists on the fact that sustainable development is closely related to the long-standing economic concept of income. Hicks (1946) defined income as ‘the maximum amount an individual can consume during a period and remain as well off at the end of the period as at the beginning’. Despite the obvious and important differences that exist between the economic affairs of an individual and those of an entire nation, we can apply the above definition of income to a nation and define it as the ‘amount that a nation can collectively spend during a period without depleting the capital base (or wealth) upon which it relies to generate this income’. It is important to note in this context that capital most crucially includes ‘natural capital’ which comprise of three principal components viz. *natural resource stocks, land and ecosystems*. As all three are essential to long-term sustainable development, it is important to consider the three critical functions rendered by ‘natural capital’ viz. *resource functions, sink functions and service functions*. Resource functions cover the natural resources drawn into the economy for converting into goods and services (e.g. mineral deposits, timber from natural forests, deep sea fish, etc.), while the sink functions absorb the unwanted by-products of production and consumption like exhaust gases, liquid and solid wastes, etc. Likewise, the service functions provide the habitat for all living beings with the essentials like the air to breathe and water to drink and are hence also called as ‘survival functions’. Therefore, if the quantity and quality of any of these functions are diminished, the biodiversity of species is itself threatened. Further, some service functions, though are not essential for survival, contribute to improving the quality of life greatly (e.g. by providing a pleasing landscape for leisure pursuits). These functions, called amenity functions, influence the quality of life of people in immeasurable terms. According to the capital approach, therefore, the long-term sustainability of development depends upon the maintenance of natural capital. If the stock of natural capital declines to the point where they are no longer able to adequately provide their functions, any pattern of development that relies on these functions becomes unsustainable.

13.4.2 The Ecological Approach

Central to the ecological view of sustainable development is the notion that economic and social systems are sub-systems of the global environment. From this, it follows that sustainability in the economic and social spheres is subordinate to sustainability of the environment. Development, from the ecological viewpoint, therefore refers to the capacity of an ecosystem to respond positively to change by maintaining the ecosystem characteristics. The key property to be sustained is the capacity of ecosystems to be resilient to external perturbations and changes. A strong current within the ecological viewpoint is the notion that the health of ecosystems must be protected and enhanced if they are to exhibit the resilience that is necessary for sustainability.

The ‘ecosystem health’ approach to sustainable development, therefore, implies issues of measurement within two broadly defined categories. The first relates to measurement of pressures placed on ecosystems by human activities (e.g. material and energy extraction, pollutant emissions, human appropriation of space and ecosystem productivity, etc.). These pressures are often the cause of reduced ecosystem health manifesting in degraded service flows and/or reduced management options. The second relates to measures of the responses of ecosystems to these human pressures. These response measures can be of four types: (i) measures that describe the state of the ecosystem; (ii) measures that describe the causes of changes in the state of the ecosystems; (iii) measures that describe the likely changes in ecosystems in the face of known pressures; and (iv) measures of the capability of ecosystems to deal with imposed pressures.

13.5 SUSTAINABILITY

The meaning of sustainability has been the subject of intense debate among environmental economists. The debate focuses on the substitutability between 'natural capital' and 'manufactured capital' and is characterised as weak if substitutability is permitted and strong if substitubility is not allowed. According to Brekke (1997): a development is said to be *weakly* sustainable if the development is *non-diminishing* from generation to generation. Since sustainable development corresponds to intergenerational equity, the non-decreasing welfare over time is viewed as a constraint on growth as even a temporary decrease in welfare is taken to imply unsustainable development. Brekke's definition refers to continuing growth of Net National Product (NNP) [defined as Gross National Product (GNP) minus capital consumption (or capital allowance to replace depreciation)]. Since GNP is commonly seen as total output of goods and services by the economy, it is often interpreted as the sum of returns to the two factors of production viz. labour and capital. Thus, sustainability is basically seen (by neoclassical economists) as a problem of managing a nation's portfolio of capital to be maintained at a constant level. It includes natural capital but either allows or imposes restrictions on substitution between man-made and natural capital.

13.5.1 Weak Sustainability

Weak sustainability refers to the maintenance of per capita income generated over time (from the total capital stock available to a nation measured in monetary terms) with no regard to the composition of the capital stock. In other words, the different forms of capital are assumed to be substitutes for each other. Weak sustainability, therefore, allows for the depletion or degradation of natural resources so long as such depletion is offset by increases in the capital stocks of other forms (e.g. investing royalties from depleting mineral reserves in factories).

Pearce and Atkinson (1995) suggests weak sustainability as: $Z = S/Y - dM/Y - dN/Y$ where Z is an index of sustainability, Y is GNP, S is national savings, dM is the rate of depreciation of man-made capital and dN is the rate of depreciation of natural capital. An economy is weakly sustainable if $Z > 0$.

Weak sustainability implicitly assumes, that savings are invested in manufactured capital or human capital and that the latter are perfectly substitutable for natural capital. Furthermore, levels are irrelevant i.e. only changes matter. An example of extreme implication of weak sustainability is that of small pacific island nation of Nauru. In 1900, Nauru was one of the world's richest phosphate deposits. However, today as a result of just over ninety years of phosphate mining, about 80 percent of the island is totally devastated. Although the people of Nauru for several decades enjoyed a high per capita income [with the income from phosphate mining (estimated to be as large as $1 billion) invested in a trust fund ensuring a steady income and thereby the economic sustainability of the island for many decades], the Asian financial crisis, among other factors, wiped out most of the trust fund plunging the people of Nauru to a bleak future. The island is now biologically impoverished with the case becoming a classic illustration of weak sustainability. It shows how while a substitution of natural capital by manufactured capital may prove rewarding in the short term, in the long run natural capital transformed into manufactured capital beyond the point of sustainability could prove disastrous.

13.5.2 Strong Sustainability

Strong sustainability requires that all forms of capital be maintained intact independent of one another. The implicit assumption in this interpretation is that different forms of capital are complementary i.e. all forms are necessary for any form to be of value. For instance, produced or production capital invested in harvesting and processing timber is of no value in the absence of stocks of timber to harvest. The proponents of strong sustainability, therefore, argue that only by maintaining both natural and produced capital stocks intact, there can be non-declining income generation. Strong sustainability is achieved by conserving the stock of human capital, technological capability, natural resources and environmental quality. In other words, for strong sustainability, while maintaining the aggregate capital stock is necessary, the sufficiency condition for the same is a non-declining natural capital stock. Thus, replacement or substitution of the depleted natural capital by any other form of capital is not allowed even at the margin.

Under the strong sustainability criteria, minimum amounts of a number of different *types* of capital (economic, ecological, social) should be independently maintained, in real physical and biological terms. The major motivation for this insistence is derived from the recognition that natural resources are essential inputs in economic production and, therefore, the aggregate welfare cannot be maximised by substituting natural capital by physical or human capital. Strong sustainability, therefore, focuses on ecosystems and environmental assets as critical in the sense of providing either unique essential services or unique irreplaceable non-use value. The ozone layer is an example of the essential service for life support while the coral reefs are examples of irreplaceable non-use value. Measuring SD thus depends on the view taken about what is necessary to achieve. Thus, while weak sustainability takes the overall stock of capital into account, strong sustainability takes not only the overall stock of capital but also pays special attention to the individual elements of environment.

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

1) State the limitation encountered in the System of Environmental Economic Accounting (SEEA).

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2) What are the three principal components of 'natural capital'? What are the critical functions that natural capital performs?

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3) Among the issues of measurement implicit in the 'ecosystem health approach' to SD, state the four types of 'response measures'.

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4) Why is inter-generational non-decreasing welfare viewed as a constraint on growth?

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5) What essentially distinguishes the two concepts of 'weak and strong sustainability'?

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6) How does Pearce and Atkinson define 'weak sustainability'?

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7) How are the necessary and sufficient conditions specified in case of 'strong sustainability'?

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13.6 INDICATORS OF SUSTAINABLE DEVELOPMENT

Economic progress has typically been interpreted as growth in human economic well-being. The association of growth with progress implies that we always wish to raise the level of progress from the level we have so far achieved. At the level of national economy [derived from the System of National Accounts (SNA)], this is approximated by the aggregate indicators of Gross National product (GNP) or Net Domestic Product (NDP). In more recent years, preparation of Green National Accounts (GNA), by incorporating for the consumption and degradation/depletion of natural resources, has received a fair amount of attention. The basic identity for GNA or Green Net National Product (G-NNP) is specified as follows:

$$\text{G-NNP} = C + S - \text{Detr } K_M - \text{Dep } K_N - \text{Deg } K_N$$

where C = consumption, S = savings, Detr K_M = deterioration of man-made capital, Dep K_N = depletion of natural capital and Deg K_N = degradation of natural capital.

The above identity states that G-NNP is equal to consumption plus the value of savings minus the sum of depreciation on the overall capital stock. When natural capital is used up, NNP is greater than G-NNP.

13.6.1 CSD Indicators and MDG

In 1992, the United Nations Conference on Environment and Development (UNCED) recognised the important role that indicators could play in helping countries make informed decisions concerning sustainable development. Under its aegis, at the international level, the Commission on Sustainable Development (CSD) [with the main objective of making the indicators of sustainable development accessible to decision makers at the national level] extensively tested, applied and used the indicators of sustainability (called CSD indicators) in many countries. Important theme areas covered by the CSD indicators are presented in Table 13.1.

Table 13.1: **CSD Indicator Themes**

• Poverty • Governance • Health • Education • Demographics	• Natural Hazards • Atmosphere • Land • Oceans, Seas and Coasts • Fresh Water • Biodiversity	• Economic Development • Global Economic Partnership • Consumption and Production Patterns

Source: U.N., 2007.

The set of first draft indicators of sustainable development was developed for discussion jointly by the Division of Sustainable Development (DSD) and the Statistics Division, both within the United Nations Department of Economic and Social Affairs. This draft then became the focus of a broad consensus-building process that included a number of organisations within the U.N. system and other international organisations, both intergovernmental and non-governmental, and coordinated by the DSD. The result was a set of 134 indicators. From 1996 to 1999, 22 countries across the world voluntarily pilot-tested the indicator set. From 1999 to 2000, the results of the national testing were evaluated and the indicator set was revised. Overall, countries considered the testing process to be successful, although they indicated that they had faced significant institutional challenges especially in the areas of human resources and policy coordination. Integrating indicator-initiatives with national development policies and transforming them into permanent work programmes ranked high among the recommendations to ensure success. Most countries also found that the initial CSD indicator set was too large to be easily managed. Consequently, the revised set of CSD indicators was reduced to 58 indicators, embedded in a policy-oriented framework of themes and sub-themes.

Later in 2005, the Division for Sustainable Development (DSD) started a process of reviewing the progress made in this direction with the additional objective of regrouping the theme areas so as to make them more homogeneous. Moreover, it also proceeded to have the coherence between the CSD and MDG set of indicators established. The newly revised CSD indicators contain a core set of 50 indicators. These core indicators fulfil three criteria. First, they cover issues that are relevant for sustainable development in most countries. Second, they provide critical information not available from other core indicators. Third, they can be calculated by most countries with data that is either readily available or could be made available within reasonable time and costs. The division of indicators along the lines of four 'pillars' (social, economic, environmental and institutional) is no longer explicit in the newly revised set. These changes, besides emphasising the multi-dimensional nature of sustainable development, also reflects the importance accorded to coordinated functioning. Consequently, new cross-cutting themes such as poverty and natural hazards were introduced and existing cross-cutting themes such as consumption and production patterns are better represented. Other new themes introduced include global economic partnership and governance. The former includes a number of new indicators that capture key issues like trade and development financing. The indicators for the theme of 'governance' are as yet not fully developed as only crime related indicators are currently included. Significant methodological work is therefore still needed to develop good, measurable and internationally acceptable indicators on several aspects of governance. It is relevant to note that 'ensuring environmental sustainability' had also been included under the eight core goals of the MDG (millennium development goals) [Box 2]. While many of the indicators overlap, the overall purpose of the two sets are different. While the CSD indicators are intended solely to provide a reference, or a sample set, for use by countries to track progress towards nationally defined goals, the MDG indicators were developed for the global monitoring of progress towards meeting the internationally established goals. The CSD indicators are designed to cover a broad range of issues pertaining to all the pillars of sustainable development (i.e. economic development, social development and environmental protection). The MDG indicators constitute an important subset of the sustainable development agenda with a strong focus on issues related to the poverty-health nexus. Sustainable development issues that are not covered by the MDG indicators include demographics, natural hazards, governance and macroeconomics.

Box 2: Millennium Development Goals

1. Eradicate extreme poverty.
2. Achieve universal primary education.
3. Promote gender equality and empower women.
4. Reduce child mortality.
5. Improve maternal health.
6. Combat HIV/AIDS, malaria and other diseases.
7. Ensure environmental sustainability.
8. Develop a global partnership.

Source: U. N., 2007.

13.6.2 Accounting Framework and Aggregate Indicators

Indicator systems based on accounting frameworks allow for sectoral aggregation using consistent classifications and definitions. The most prominent example in this regard is the System of Integrated Environmental and Economic Accounting (SEEA) pioneered by the United Nations Statistical Commission (UNSC). The SEEA extends national accounting to environmental aspects by allowing for the construction of a common database. Although several countries are using the SEEA, it is still in the developmental stage as it has not yet succeeded in adequately taking into account two of the four pillars of sustainable development viz. the social and institutional pillars. These concerns are being addressed through efforts to expand the system by incorporating human capital and by exploring the possibility of linking the accounting frameworks with social accounting matrices (SAM) developed in consistency with the national accounts. Implementation of the SEEA would improve the sustainable development indicators embedded in capital frameworks as well as those based on thematic frameworks. In case of capital frameworks, the SEEA facilitates moving from modelled and estimated data towards directly obtained capital measures. For thematic frameworks, the SEEA is especially useful if the indicators are used for monitoring and evaluation of development strategies. By basing indicators in a consistent database, allowing for meaningful sectoral and spatial disaggregation, progress towards specific targets included in a strategy as well as cross-sectoral impacts can be assessed.

Aggregate indicators [like the Ecological Footprint, the Environmental Sustainability Index (ESI) and the Environmental Performance Index (EPI)] are aimed at measuring the biological/ecological capacity of economies. For instance, the Ecological Footprint (originally developed by Wackernagel and Rees, 1996) translates human resource consumption and waste generation into a measure of biological productive entity (like land and water). The ESI integrates 76 data sets (tracking natural resource endowments, past and present pollution levels, environmental management efforts and the capacity of a society to improve its environmental performance) into 21 indicators and finally into a single index. The EPI aggregates 16 indicators related to resource depletion, pollution, environmental impact and energy efficiency into an index aimed at measuring policy impact on environmental performance.

13.7 APPLICATION OF INDICATORS TO NATIONAL DEVELOPMENT STRATEGIES

The selection of indicators is to a large extent determined by the purpose of the indicator set. Right from its inception, the overarching purpose of the CSD indicators has been to inform policy at the national level. In addition to using indicators to assess overall progress towards sustainable development, many countries have successfully used them to develop their national sustainable development strategies (NSDS). Aside from their basic purpose, there are other important criteria for selecting indicators for sustainable development. From the beginning, the CSD indicator guidelines (and methodologies) have recommended that indicators for sustainable development should be:

- primarily national in scope;
- relevant to assessing sustainable development progress;
- limited in number, but remain open-ended and adaptable to future needs;
- understandable, clear and unambiguous;
- conceptually sound;
- representative of an international consensus to the extent possible;
- within the capabilities of national governments to develop; and
- dependent on cost effective data of known quality.

The first criterion emphasizes the importance of using the indicators for national level assessment. Criteria two through four, taken together, pose a challenge emphasising on the indicators to be limited but sufficiently comprehensive to capture the multidimensional nature of sustainable development. Clearly, if too many indicators are used, the results become unwieldy and difficult to interpret. For instance, the CSD indicator originally began with 134 indicators, but testing in field by countries led to their drastic reduction.

The introduction of smaller core set within the larger set have made the sustainable development indicators more manageable. Size will in general be influenced by purpose i.e. as the purpose of the indicators narrow, their number decreases.

Given that ambiguity is relative to context, clarity of purpose will bring in clarity in indicator. For instance, in a country with low food security, an increase in arable crop-land would be positive, whereas in a country with agricultural overproduction due to subsidization, it would be negative. The existence of voluntary targets for indicators at the national level will help to avoid such ambiguity. In many cases, linkages among thematic issues easily lead to potential conflicts. For instance, high GDP growth is generally considered a positive sign of economic development, but it is often associated with higher energy consumption, exploitation of natural resources and negative impacts on environmental resources. Nevertheless, in many cases, it has also positive impacts on poverty alleviation. These potential conflicts should therefore not be seen as signs of ambiguity. Rather, such cases reinforce the need to interpret the results in a balanced and integrated manner.

Indicators should be conceptually sound. However, in new areas of interest, the demand for an indicator usually precedes its development. In such cases, it is advisable to benchmark the indicator with a generic description and gradually increase efforts to develop its conceptual underpinnings. In the meantime, a proxy indicator may be used as long as there is sufficient evidence that it is able to capture relevant phenomena that do not skew the results.

Despite major advances over the last decade, data availability and reliability continue to be a problem in many countries. To increase cost effectiveness, the CSD indicators often require data that are routinely collected either by national statistical services or through international processes (e.g. for the latter is the work of United Nations specialized agencies in the MDG context). Many indicators rely on data contained in national accounts and progress made in the adoption of the system of national accounts (SNA). Implementation of the system of environmental-economic accounting (SEEA) will go a long way in improving the integrated analysis of the indicators necessary for developing appropriate policy interventions.

13.8 SUSTAINABLE DEVELOPMENT PRACTICES IN INDIA

One of the chief merits of Green accounting is that it overcomes the shortcomings of the traditional approach of the System of National Accounts (SNA) which does not include the contribution of natural resources into the national accounts of an economy. By having an environment adjusted domestic product, policies can be designed to enhance economic growth without extensive natural resource depletion thereby achieving more sustainable income. The gap between GDP and the environmental adjusted GDP quantifies the extent of depletion and degradation sending important signals to take necessary policy actions. India has initiated studies on Natural Resource Accounting (NRA) with the ultimate objective of building up Green-GDP for the Country. The Central Statistical Office (CSO) has been working on a methodology to systematically incorporate natural resources into national accounts in different states for land, water, air, and sub-soil assets. A recent initiative by the Green Indian States Trust (GIST) aims to set up top-down economic models for annual estimates of adjusted Gross State Domestic Product (GSDP) for all Indian States. Aimed at capturing true 'value addition', the study's approach is expected to provide a consistent and impartial national framework to value the unaccounted aspects of national and state wealth and production in a manner to be useful for policy analysis.

Notwithstanding the above, the efforts till date in India towards incorporating the natural resources in its national income are far less than what is required for an informed decision on sustainable development policy. This requires speeding up the research activities which facilitate better valuation techniques for the environmental resources. An increased participation of the government, both state and central, is necessary to invoke far more seriousness in this regard. Equal emphasis on economic approaches, as with the accounting approach, should be laid to come up with a strong base of environmental accounting in India. Construction of environmental indicators, which would suggest the depletion values of specific natural resources would help in this direction.

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

1) State the identity for Green-NNP specifying its constituents.

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2) In what way the CSD & MDG indicators together assist in policy planning?

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3) How is SEEA seeking to address the inadequate representation of 2-pillars of SD viz. social and institutional pillars?

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4) What are ‘aggregate indicators’? Give some examples.

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5) What are the important criteria that are expected to be met by the CSD indicators?

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6) In what way Green GDP is helpful in initiating policy actions?

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7) What is a major initiative taken by India towards the goal of developing a Green-GDP estimate?

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13.9 LET US SUM UP

The multi-disciplinary and inter-disciplinary character of the concept of 'sustainable development' is clearly underscored. In this light, given its structural characteristics of non-linearity, resilience and irreversibility, the unit explains the different interpretations that flow from the various definitions on sustainable development available in the literature. There are two mainstream approaches of measuring sustainability viz. the capital approach and the ecological approach. The difference between allowing for the substitutability of 'natural capital' with that of 'manufactured capital' to ensure that the stock of capital is not depleted (i.e. the concept of 'weak sustainability') and keeping the different constituents of natural capital maintained at some levels by not allowing for such substitution (called as 'strong sustainability') is then explained. The two major indicators of sustainability that have come to be recognised for adoption by countries viz. the CSD indicator and the MDG/SDG indicators (which includes environmental sustainability as one of its goals) and the challenges that have continued to remain in their successful development and implementation (particularly in incorporating the governance parameters) is discussed. Issues relating to application of sustainable development indicators to national development strategies and the steps taken in this regard by India have been outlined.

13.10 KEY WORDS

Ecosystem Health	Ecosystem health is a metaphor derived from the human health sciences. In simple terms, it can be thought of as a resource that enables ecosystems to adapt and evolve in the face of changing circumstances.
Ecological Footprint	Refers to the impact of human activities measured in terms of the area of biologically productive land and water required to produce the goods consumed and to assimilate the wastes generated.

	More simply, it is the amount of the environment necessary to produce the goods and services necessary to support a particular lifestyle.
Hicksian Sustainability	Hicksian sustainability, requires non-decreasing consumption — including consumption of environmental goods and services.
Hartwick-Solow Sustainability	'Hartwick-Solow sustainability' is defined in terms of maintaining the total capital stock of society.
Hicks-Hartwick-Solow Weak Sustainability	Hicks-Hartwick-Solow weak sustainability by Pearce and Atkinson (1995) states that Z = S/Y - dM/Y - dN/Ywhere Z is an index of sustainability, Y is GNP, S is (national) savings, dM is the rate of depreciation of man-made capital and dN is the rate of depreciation of natural capital. An economy is weakly sustainable if Z > 0.
SDGs	The SDGs was generated as a parallel concept to MDGs that became popular at the Earth Summit in Rio de Janeiro in 1992 and at Rio +20 summit in 2012. The SDG agenda involves goals in the area of clean air, biodiversity and also refer to the preservation or establishment of global public goods (limiting climate change, financial stability) that can be measured through macro-indicators. They are not objectives, but preconditions for sustainable development.

13.11 SUGGESTED REFERENCES FOR FURTHER READING

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13.12 ANSWERS/HINTS TO CYP EXERCISES

Check Your Progress 1

1) See 13.2.1 and answer.
2) See 13.2.2 and answer.
3) See 13.2.2 and answer.
4) See 13.3 and answer.
5) See 13.3 and answer.
6) See 13.3 and answer.
7) See 13.3 and answer.

Check Your Progress 2

1) See 13.4 and answer.
2) See 13.4.1 and answer.
3) See 13.4.2 and answer.
4) See 13.5 and answer.
5) See 13.5.1 & 13.5.2 and answer.
6) See 13.5.1 and answer.
7) See 13.5.2 and answer.

Check Your Progress 3

1) See 13.6 and answer.
2) See 13.6.1 and answer.
3) See 13.6.2 and answer.
4) See 13.6.2 and answer.
5) See 13.7 and answer.
6) See 13.8 and answer.
7) See 13.8 and answer.

UNIT 14 GREEN ACCOUNTING AND ENVIRONMENTAL COST BENEFIT ANALYSIS

Structure

14.0 Objectives

14.1 Introduction

14.2 System of National Accounts: Theory and Practice

14.3 Gaps in Conventional System of National Income Accounts

14.4 Requisite Modification in the Conventional National Income Accounts

- 14.4.1 Physical Accounting
- 14.4.2 Pollution expenditure Accounting
- 14.4.3 Development of Green Indicators
- 14.4.4 Extension of the SNA-Type Systems

14.5 Usefulness of Environmental Accounting

14.6 Environmental Cost Benefit Analysis

- 14.6.1 Applications of ECBA
- 14.6.2 Valuation of Environment
- 14.6.3 Limitations of ECBA

14.7 Let Us Sum Up

14.8 Key Words

14.9 Suggested References for Further Reading

14.10 Answers/Hints to CYP Exercises

14.0 OBJECTIVES

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

- explain the system of national income accounts (SNA);
- state the limitations of the conventional system of national income accounts;
- discuss the methods of modifying the conventional national income accounts;
- outline the usefulness of environmental accounting;
- discuss the method of environmental cost benefit analysis (ECBA);
- describe the methods of valuation of environment; and
- enumerate the limitations of ECBA.

14.1 INTRODUCTION

National accounts provide a description of the state of the economy and a database useful for macroeconomic analysis. Measures such as gross domestic product (GDP) and gross fixed capital formation (GFCF) generated by the national accounts have for long been used for economic progress evaluation and policy design and recommendations. However, for more than two decades now it has been recognised that conventional indicators of economic growth like GDP/GNP are incomplete as they have not been designed to account for environmental asset's contribution/depletion in the process of economic growth such as deteriorating quality of air and water, depletion/ degradation of natural resources (e.g. minerals, soil quality), etc. With increasing public demand for cleaner environment and policy focus on growth-environment trade-off, a need is felt to integrate the accurate supply and use of natural and environmental resources into the national accounts system. As already studied in Unit 2, environment is a source of both raw material, amenities and sink for wastes generated as a result of economic activities. Green accounting aims at incorporating the environmental service flow into the national income accounts by suitably quantifying the contribution of such assets into the income stream and augmenting the capital/asset account by including the addition or depletion of natural capital/asset. For green growth, investment projects having significant impacts on environmental resource should ideally be evaluated from social point of view for which the method of Environmental Cost-Benefit Analysis (ECBA) is useful. The present unit makes a brief review of the existing 'system of national accounts' (SNA) followed by an account of its major shortcomings. The methods by which the existing shortcomings can be rectified are also discussed.

14.2 SYSTEM OF NATIONAL ACCOUNTS: THEORY AND PRACTICE

"The System of National Accounts (SNA) is the internationally agreed standard set of recommendations on how to compile measures of economic activity. The broad objective of the SNA is to provide a comprehensive conceptual and accounting framework for compiling and reporting macroeconomic statistics for analyzing and evaluating the performance of an economy" (United Nations Statistics Division). The SNA lays down the accounting rules which are to be followed internationally for measurement of indicators like Gross Domestic Product (GDP), Net Domestic Product (NDP), Gross Fixed Capital Formation (GFCF), Gross Savings, etc. The SNA is periodically revised to incorporate latest methods and desired practices. For instance, beginning with the SNA 1947 (which reflected the Keynesian macroeconomic approach emphasising on major aggregates like consumption, savings, investment and government expenditures following the period of the Great Depression), the SNA has subsequently been revised in 1953, 1960, 1964 and 1968. More recently, the SNA was revised in 1993 and then in 2008. The SNA categorizes the national income accounts into three major heads of accounts viz. (i) current accounts, (ii) asset accounts (also called as accumulation accounts) and (iii) a balance sheet for different sectors (SNA 1993, 2008).

Current Accounts: Current accounts deal with the reporting of the production of goods and services including the generation, distribution and use of income. Under this, GDP is measured as the sum of the value added from all economic activities carried out within a country's territory plus 'net indirect taxes' (i.e. indirect taxes minus subsidies). It is thus a value added identity (to be summed up over all the sectors of economic activity) expressed as:

Gross Value Added = Output – Intermediate Consumption + Net Indirect Taxes ....(14.1)

or Net Value Added = Gross Value Added – Consumption of Fixed Capital ....(14.2)

The above approach, called as the production approach, is one of the three methods by which the GDP is measured. The other two approaches are what are known as the 'income approach' and the 'expenditure approach'. The GDP estimating identities of these two approaches are respectively expressed as:

GDP = Compensation of Employees + Gross Operating Surplus + Gross Mixed Income + Net Indirect Taxes ....(14.3)

GDP = Consumption + Government Spending + Gross Capital Formation + Net Exports ....(14.4)

Asset Accounts and the Balance Sheet: 'Assets' in SNA are defined as 'entities owned by some unit, or units, from which economic benefits are derived by their owner(s) over a period of time' (SNA 2008). Assets may be synthetic (produced economic assets) or grown naturally (non-produced economic assets such as mineral deposits, land, etc). The definition of assets includes financial as well as fixed assets (e.g. machinery, equipments, structures, cultivated biological resources, etc). SNA 2008 categorizes five types of natural resources: (i) land, (ii) mineral and energy reserves (recoverable using current technologies), (iii) non-cultivated biological resources, (iv) water-resources and (v) other natural resources (e.g. radio spectra). All environmental assets having effective ownership rights (either private or government owned) such as land, fuel reserves, mineral deposits, orchards, timber tracts, livestock for breeding, private plantations, etc. are included in the SNA. On the other hand, economically un-exploitable minerals, resources having no proper ownership rights such as air and oceans, common property resources lacking effective control and undiscovered mineral deposits are not included in the SNA. One reason why these are kept outside the purview of SNS is that the contribution of such resources cannot be measured easily.

The SNA classifies the assets or accumulation accounts under four heads viz. (i) the capital account, (ii) the financial account, (iii) changes in the volume of assets account (actually indicated by the SNA as '*other* changes in the volume of assets account') and (iv) the revaluation account. The products of economic assets are identified by the SNA under these four heads of accounts. Out of these, the first two accounts viz. the capital account and the financial account relate to changes in assets, liabilities and net worth due to savings and capital transfers. While the financial accounts record transactions in financial assets and liabilities, the capital account records the transactions in non-financial assets. The second group of accounts i.e. changes in volume of assets account and the revaluation account relates to changes in assets, liabilities and net worth due to other factors. In this, the 'changes in the volume of assets account' records the effect of exceptional events that cause the volume and value of assets and liabilities to change. The revaluation accounts records the changes in the value of assets due to changes in price level.

The 'changes in volume of assets account', besides serving the important function of recording the changes in assets due to catastrophic losses, also records the discoveries/extractions and upward/downward reappraisals of subsoil resources like oil, coal and natural gas. It records the natural growth of uncultivated biological resources (e.g. fish stocks, natural forests) and the entry/exit of natural resources to and from the asset boundary. Taking the produced and the non-produced natural assets together, the 'balances' are identified in the SNA as:

Closing Stock = Opening Stock + Gross Capital Formation – Consumption of Fixed Capital + Other Changes in Volume of Assets + Holding Gains/Losses in Assets .... (14.5)

In India, the national accounts and macroeconomic aggregates (such as GDP, NDP, GFCF, CFC, etc.) are published annually in the publication National Accounts Statistics (NAS). The publications of NAS are frequently revised to effect the change of base year (to a year of recent time point so as to reflect the changing price levels realistically) and include data on such new variables which have since become available. The NAS was revised in 2010 to incorporate the 1993 and 2008 SNA recommendations and change the base year to 2004. Subsequently, the base year has been upgraded to 2011-12. Many important environmental considerations are incorporated into the NAS in its current and accumulation accounts. For instance, GDP includes the output of dung manure, the value of natural growth of cultivated assets for certain crops, the value of fuel wood, timber and non-timber forest products extracted from forests depending on data availability on prices and outputs. Likewise data on Gross Capital Formation (GCF) is extended to include capital investment by households in wind energy systems and bio-gas plants, outlays on land improvements and development of plantations, mining sites and timber tracts and capital expenditures incurred on installation of wind energy installation systems. Many more variables which account for environmental considerations are yet to be accounted for in the NAS. For instance, in case of land, variables which are not included in the national accounts are depletion of land, impact of disasters, productivity of land, degradation of soil, etc. In case of forests, variables such as deforestation, mangrove cover, biodiversity, etc are not included. In case of minerals, pollutant loads from mining and depletion of minerals are not included. In case of atmospheric quality, SO_2, CO_2, Suspended Particulate Matter (SPM), carbon monoxide, nitrogen dioxide, fuel consumption, ozone depleting substances, among others, are yet to be accounted for. Surface and ground water quality, sedimentation in water ways and their treatment costs are few other variables which are as yet unaccounted in the national accounts.

14.3 GAPS IN CONVENTIONAL SYSTEM OF NATIONAL INCOME ACCOUNTS

The conventional system of national accounts basically reflects the Keynesian macroeconomic model which mainly focuses on measurement of consumption, investment in physical capital, savings and government expenditures. It thus largely ignores environmental/natural assets and flows there from. Since an economy cannot function without natural assets, natural resources must be explicitly accounted for in the national accounts so as to both reflect for their contribution and signal for their non-sustainable exploitation. In this context, measurement of natural resources is important for their effective management. While the requisite modifications in the SNA will be discussed in detail in section 14.4, the main shortcomings in the conventional system of national accounts are stated here.

1. According to classical economists, income is the return on land, labour and capital. In the standard neo-classical production function, there are only two primary factors of production – labour and capital. Neoclassical theory did not thus perceive land as distinct from capital. Hence, value addition is considered primarily through these inputs.

2. Economic activities use natural resources as inputs and produce outputs along with wastes/emissions as by-product. The conventional SNA standards do not recognize this role of environmental factors/natural resources as inputs in economic production as they are considered as intermediate inputs or are not exchanged through market with well defined property rights. For instance, waste disposal

services provided by nature are not recognized as inputs because they lack market value.

3. In the conventional SNA system, along with man-made capital assets, natural assets are not treated on same footing. For that reason, not only that GDP does not account for natural capital depreciation, but GDP can go up with increase in final output from depletion of soils, forests and minerals. For instance, the national accounts record the positive contribution of expenditures incurred in clearing forests for non-forest purposes, but the losses of forest inflicted on the society in the process is not recorded. Just as machineries depreciate, soils also depreciate due to loss in its fertility. Infertile soil has less future income potential. The NDP estimates in the conventional SNA adjusts for depreciation through Consumption of Fixed Capital (CFC) only for man-made assets. It does not account for depreciation or depletion of environmental assets as the CFC is not computed for non-produced assets like land and mineral deposits.

4. The non-monetised and non-marketed goods and services are underestimated in the conventional GDP. For instance, in forestry, while timber and non-timber forest products contribute to GDP, other forest services like flood control, carbon sequestration, protection from soil erosion, amenity values, etc. are not included as such services cannot be easily monetized/exchanged through market. In other words, primarily, the focus in conventional GDP is on marketed goods and services and non-marketed goods and services are ignored.

5. Due to the above factors, GDP will actually increase with decline in forest cover even though forests based timber output positively contributes to GDP as GDP includes the marketed value of timber. Another example is air pollution. When pollution rises, air pollution has negative impact on health. But with increased demand for medical services, consumption expenditure on health rises which tends to increase GDP.

6. Changes in environmental/natural assets also have distributional implications which are ignored by conventional GDP. For instance, regions dependent on natural resources may become poorer with increase in resource depletion. This may widen the gap between the developed and under-developed regions. Disappearing forests and wildlife and severely polluted air do not affect measured income in the present national accounts. Even low-income countries dependent on natural resources use national accounting system which ignores their natural assets. Such an accounting system implicitly assumes that natural resources are available in plenty. Natural assets, strictly speaking, are assets which effectively contribute to economic productivity in multiple ways, irrespective of whether they are directly reflected in the market exchange or not. Conventional system of national accounts conveys a false impression that income is rising even when our natural wealth is degrading. Such measures of income are inadequate for measuring the true welfare as they fail to indicate whether the growth process is environmentally sustainable. Persistent usage of an ‘incorrect yardstick’ of sustainable economic growth will have damaging consequences for the economy and the environment. Environmental accounting is therefore a rightfully required step in the recognition of growth-environment linkages and is also crucial for incorporating in policy decisions.

Check Your Progress 1 (answer the questions in about 100 words within the space given)

1. What are the three major heads of accounts in which the SNA is categorized? To which of these accounts the production value of goods and services accounted?

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2. What are the three methods by which national income is measured? Specify the equations for estimating the GDP under each of these methods.

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3. How are 'assets' defined in SNA? Specify its types and components.

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4. Which type of environmental assets are normally included under the SNA classification? Which ones are not included and why?

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5. State the four heads of accounts into which the products of economic assets are classified in the SNA.

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6. What function does the 'changes in volume of assets account' serve? In this, taking into account both the produced and the non-produced natural assets, write the equation by which the balance of capital stock is estimated in the NAS?

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7. Why does the conventional SNA not account for depreciation of environmental assets?

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8. Why are the forest services like flood control and carbon sequestration not accounted for in the conventional SNA?

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14.4 REQUISITE MODIFICATIONS IN THE CONVENTIONAL NATIONAL INCOME ACCOUNTS

To overcome the shortcomings of the conventional national income accounting represented through the SNA framework, two types of adjustments are required. The first one requires defining and valuing non-marketed environmental goods and services. The second area is in respect of measuring and valuing the changes in the stock of natural resources. For instance, in the area of forests, one should extend the traditional NDP by accounting for the non-marketed benefits associated with forests. In addition, it should also be adjusted for the value of change in forest as asset . While the consensus for greening the traditional SNA is widely accepted, the approaches suggested vary ranging from 'conserving the stock of environmental assets' to 'taking into account the effect of environmental change on welfare'. The various approaches could be broadly grouped into four major categories viz. (i) physical accounting, (ii) pollution expenditure accounting, (iii) development of green indicators, and (iv) extension of the SNA type systems in terms of two main approaches viz. system of integrated environmental and economic accounting (SEEA) and environmental and natural resource accounting framework (ENRAP).

14.4.1 Physical Accounting

According to this approach, physical information on status of environment should be used to supplement the conventional national accounts. For instance, in case of forests, data on physical indicators such as volume of timber stock, area under dense forests, open forests, etc. can be taken into account. In case of air quality, data on emissions of CO_2, SO_2, SPM, carbon monoxide, etc. can be considered. In case of water quality, data on physical indicators such as Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), dissolved oxygen, pH factor, etc. can be considered. Such information can be integrated with conventional input-output matrices. For instance, EUROSTAT has developed a tool called NAMEA (National Accounting Matrix with Environmental Accounts). Such a tool is useful for analyzing the economy-environment linkages. It can trace which economic activity is responsible for a particular type of emission.

While physical indicators such as CO_2 emissions per capita or wastes per capita are preferred by few environmental economists, there are some limitations to this approach. Physical indictors do not indicate the monetized value of environmental costs and benefits. Another shortcoming of this approach can be illustrated with the help of an example on forests. Forests can be measured by volume of timber, area under forests, number of species of flora and fauna, etc. But the units of measurement are varied as volume is measured in cubic meters, area in hectares and species in numbers. Incomparability of units of measurement makes this approach less suitable for use in policy making. The choice of appropriate measurement unit depends on the precise policy objective. For instance, forests can be used for preserving biodiversity or management of timber resources. Moreover, this approach fails to give a condensed description due to the use of dissimilar units. Hence, it fails to indicate how severe is the environmental problem. This approach also requires the establishment of huge data sets as different indicators are to be constructed for air, water, forests, etc. Hence, it does not help to draw conclusions on economic and environmental significance of assets.

14.4.2 Pollution Expenditure Accounting

This approach basically involves development of data series on environmental expenditures such as pollution abatement. U.S. and OECD countries have maintained such data series. Such an approach helps to indicate the effect of environmental policies on productivity. However, it is also subject to some limitations. Such expenditures should not be taken as additions to traditional national accounts because they are already incurred expenditures reclassified as environmental expenditures. Moreover, such expenditures have a tendency to exaggerate the actual opportunity costs as they include material costs which are already included in the value added of the sectors which produce these materials. They, thus, increase the chances of double counting.

14.4.3 Development of Green Indicators

Many indicators to incorporate environmental and unpaid services have been developed over the years. For instance, a measure brought out by Nordhaus and Tobin called 'Measure of Economic Welfare' (MEW) in 1972 adjusts GDP for unpaid work, value of leisure time, industrialization externalities and environmental damages. Another measure is *Environmentally Adjusted NDP* or *EDP*. Resource extraction leads to both environmental degradation and depreciation of natural capital assets. Since improvement in the quality of environment may also increase the value of natural capital, EDP is obtained by adjusting NDP for 'net annual change in value of natural capital'. EDP deducts depreciation of man-made capital and natural capital from GDP ensuring consistency in treatment of both man-made and natural assets. However, this approach requires that natural capital depreciation should be estimated in monetary terms. Further, it may hide the real value of resource depletion expressed in physical terms. For instance, decline in volume of timber resources may go unnoticed if there is an increase in the value of timber resources due to rise in market prices.

The concept of '*comprehensive wealth*' as a measure of sustainable growth has also been attempted. Comprehensive wealth is defined as the shadow value (i.e. true opportunity cost) of all capital assets in the economy. Capital assets are defined in a broader sense to include physical capital, human capital, natural capital and social capital. While human capital is basically the knowledge, skills and health embodied in humans, social capital refers to institutions like efficient judicial system, well-defined property rights, etc. World Bank (2006 and 2011) has generated comprehensive wealth estimates for various countries. The International Human Dimensions Programme on Global Environment Change (by United Nations University) releases an Inclusive Wealth Report

(IWR) every two years providing the 'Inclusive Wealth Index' for various countries. In India, an Expert Group set up to suggest a system of 'Green National Accounting' has pointed out that 'Green GDP is a misnomer' and it is the 'wealth' of a nation which should be ideally measured. Work on deriving wealth estimates for India is in progress.

Adjusted Net Savings (or 'Genuine Savings') is another indicator of sustainable growth published by the World Bank. It is obtained by deducting the value of natural resource depletion and value of damages from pollutants from the traditional net national savings. Additionally, expenditure on education is added to the net national saving since it enhances human capital. The adjusted national accounting (or green accounting) is preferred over qualitative indices such as the Environmental Sustainability Index (ESI). The ESI is constructed using 21 indicators of 5 types viz. state of environmental systems, human vulnerability, stewardship, level of risks and social/institutional capacity. In contrast to a green accounting exercise, ESI cannot answer whether economic growth is environmentally sustainable. Few other such indices are Ecological Footprint, Biocapacity and Ecological Debt, Human Well-Being Index, etc.

14.4.4 Extensions of SNA-Type Systems

Building upon the existing SNA, covering all the sectors that interact with the environment rather than just one element such as depreciation or pollution abatement expenditure, has been another direction in which work has gone on towards green accounting. Under this, two approaches viz. the 'system of environmental and economic accounting' (SEEA) and the 'environmental and natural resource accounting framework' (ENRAP), both requiring sector-specific information, are discussed here.

System of Environmental and Economic Accounting (SEEA): There are three parts to the SEEA approach viz. the 'central framework', the 'experimental ecosystems accounts' (EAA) and the 'extensions and applications'. The 'central framework' integrates environmental information measured in physical terms with economic information measured in monetary terms. The EAA describes ecosystem measurement in physical terms and ecosystem valuation with market valuation rules. SEEA's 'extensions and applications' presents various monitoring and analytical approaches that can be adopted using SEEA data and describes how SEEA can be utilized for policy purposes.

The SEEA 'central framework' covers measurement in three important areas viz. (i) physical flow of energy/materials, (ii) stocks and flows associated with environmental assets and (iii) economic activity and transactions related to the environment. The 'physical flow of energy materials' includes: (a) flows of natural inputs from the environment to the economy such as water, minerals, timber, etc.; (b) flows of residuals from the economy to the environment such as emissions, solid waste, etc.; and (c) product flows within the economy. The 'stocks and flows associated with environmental assets' focuses on material benefits derived directly from using environmental assets (e.g. natural inputs) and ignores non-material benefits derived indirectly from using environmental assets (e.g. water purification, carbon storage and other benefits flowing from ecosystems). Individual elements embodied in individual assets are not considered separately. For instance, various nutrients present in the soil are not taken as individual assets. The 'economic activity and transactions related to the environment' area covers those economic activities which reduce environmental pressures (like pollution abatement and sustainable resource management). Other environmental transactions such as taxes, subsidies, grants and rents are also recorded here. A separate account viz. the 'environmental protection expenditure account' (EPEA) in the SEEA central framework provides information on the output of environmental protection specific services produced across the economy and the expenditure of resident units incurred for environmental protection purposes.

The SEEA 'central framework' uses a series of tables and accounts to provide information on stocks/flows related to the economy and environment. These are: (i) supply and use tables in physical and monetary terms showing the flows of natural inputs, products and residuals; (ii) asset accounts for individual environmental assets in physical and monetary terms showing the stock of environmental assets at the beginning and at the end of each accounting period and the changes in the stock; (iii) a sequence of economic accounts highlighting depletion-adjusted economic aggregates; and (iv) functional accounts recording transactions and other information about economic activities undertaken for environmental purposes. The SEEA 'central framework' is broadly consistent with the SNA. Both the SEEA 'central framework' and the SNA use the same market price valuation principles for valuing environmental assets. However, there are few differences between them. For instance, the SEEA 'central framework' recommends recording all intra-enterprise flows (i.e. production and use of goods and services on own account within enterprises) depending on the analytical scope of the account being compiled. The SEEA 'central framework' also encourages recording of household own account production. In contrast, SNA only records production of goods for own final use and intra-enterprise flows related to ancillary activities. Both SNA and SEEA 'central framework' recognize the value of natural resource depletion. But, natural resource depletion is placed in 'other changes in the volume of assets' account in the SNA. Hence, SNA does not recognize resource extraction as a cost against earned income whereas the SEEA 'central framework' does recognize resource extraction as a cost against income by giving 'depletion adjusted balancing aggregates'. Broadly, however, the asset boundaries of SEEA central framework and SNA are the same in monetary terms i.e. only assets having economic value as per SNA valuation principles are included in the SEEA central framework. In physical terms, however, the asset boundary of SEEA central framework is broader as it includes all natural resources and areas of land of an economic territory that may provide resources and space for use in economic activity. In physical terms, SEEA Central Framework is not restricted to only 'assets having economic value'. Likewise, while SNA includes land under the broad category of natural resources, the SEEA central framework recognizes land's distinct role in provision of space and treats it separately from other natural resources.

In totality, the asset boundary of SEEA is much broader as compared to SNA as it relaxes the criteria that assets must have ownership rights and also includes assets which do not provide direct economic benefit like the ecosystems. The distinction between SNA and SEEA asset boundary is illustrated in Figure 14.1.

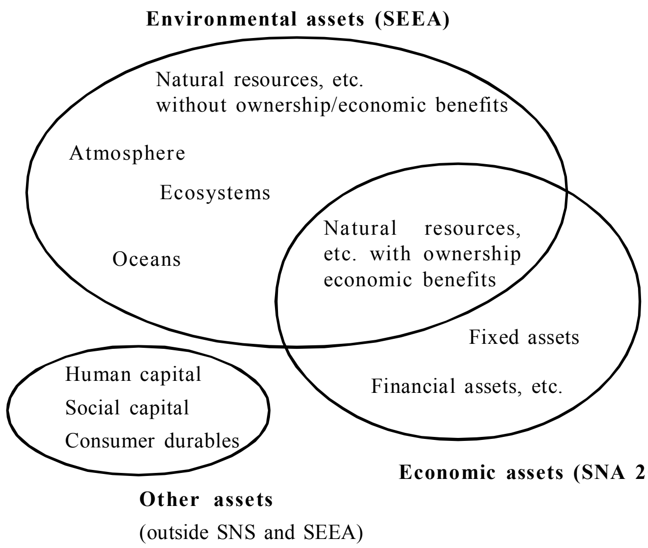

Figure 14.1: Assets in SNA and SEEA

Environmental and Natural Resource Accounting Project (ENRAP): The ENRAP (also known as Peskin framework) starts from the conventional national accounts but is more consistent with economic theory than with SNA. SEEA adheres more to SNA principles rather than economic theory. The basic idea of ENRAP is that an economic account should include all economic inputs and outputs that comprise an economic system for which the inputs and outputs need not necessarily have market prices in order to be classified as 'economic'. Rather, they must be scarce enough so that, if they are marketed, they have a non-zero price. The natural environment is a major source of non-marketed input which is economically scarce. ENRAP therefore expands traditional accounts to incorporate the input/output service of non-marketed but yet scarce environmental capital. Essentially, three categories of non-marketed natural goods and services are excluded from traditional accounts even though they are economic. These are: (i) input services (e.g. waste disposal services), (ii) output or environmental quality services (e.g. recreation services) and (iii) negative outputs (e.g. pollution). The ENRAP approach appends these non-marketed services to the marketed services which are already considered in the national accounts. Shadow prices are used to estimate the monetary value of such non-marketed services.

Check Your Progress 2 (answer the questions in about 100 words within the space given)

1. What are the two areas in which adjustment is required in order to remove the shortcomings of the conventional SNA system? Give illustrations.

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2. In which two directions the work on greening the conventional SNA framework has taken place? What are the four groups into which they can be classified?

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3. What does the method 'physical accounting' approach basically entail? What are its limitations?

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4. What are the limitations of the 'pollution expenditure accounting' approach in using it for improving the conventional SNA for environmental accounting?

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5. How is the Environmentally Adjusted NDP or EDP estimated? What problems are encountered in considering EDP for green accounting?

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6. State the major differences between SEEA and the SNA.

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7. What is the basic idea behind ENRAP? In what respects does ENRAP differ from SEEA?

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14.5 USEFULNESS OF ENVIRONMENTAL ACCOUNTING

Green Accounting has important policy implications especially for developing economies which are dependent on natural resource based activities such as agriculture, fishing, forestry, etc. In these economies, one gets inflated national income estimates if depletion of natural capital goes unaccounted. Green accounting provides a framework which facilitates designing of policies that encourage sustainable economic growth without exerting excessive pressure on natural capital or helps in identifying areas of investment in natural capital maintenance or improvement. Towards this, 'environmentally adjusted NDP' or EDP which assigns a monetary value to depreciation of natural capital assets is helpful in encouraging the formulation of policies for better environmental protection. Revenue from extraction of resources, if used to finance investment in physical and human capital besides encouraging adoption of pollution reducing practices, would contribute to balancing the ill-effects of economic growth as reflected in the unadjusted conventional GDP. In this context, indicators such as *comprehensive wealth* and *inclusive wealth index* reflect whether the *wealth* of the nation is increasing or decreasing over time. Such indicators can therefore be used for cross-national comparisons i.e. to indicate which economies are growing sustainably and which ones need to implement stricter environmental standards for sustainable growth.

An example will illustrate the usefulness of green accounting. Consider a hypothetical economy which exploits its natural resources for financing development expenditures.

GDP growth rate is given to be 8 percent per annum. Let the depreciation estimates include both physical capital and resource depletion in selected sectors like timber, petroleum and soil. Discounting for these, the NDP growth rate is only 4 percent per annum. This example illustrates how GDP paints a disguised picture of growth ignoring the erosion of the capital asset base of the economy i.e. capital inclusive of natural capital. With green accounting, policy makers would not be under the false impression that the economy is doing well and there could be compensatory growth resulting from investment made from pollution abatement expenditure and revenues.

14.6 ENVIRONMENTAL COST BENEFIT ANALYSIS

Environmental Cost Benefit Analysis (ECBA) refers to social evaluation of investment projects and policies that involve significant environmental impacts. Environmental protection agencies frequently use ECBA to analyze the environmental impacts of economic projects such as highway construction. Environmental regulations and policies are also subject to cost-benefit analysis to judge their implications. Basically, Cost Benefit Analysis refers to social appraisal of projects taking into account their consequences over time. ECBA extends this notion to incorporate the environmental impacts of the projects. Environmental impacts are generally positive or negative externalities emanating from the environment. In ECBA, the environmental impacts are assigned a monetary value for weighing costs and benefits. Since environmental goods and services (like clean air) do not have observable market price, economic valuation or measurement of the environment is crucial for its management.

In a typical Cost Benefit Analysis, increases in well-being or utility of individuals are classified as 'benefits' and decreases in well-being or utility of individuals are classified as 'costs'. A project is allowed to go ahead if 'social benefits' are found to be higher than 'social costs'. Benefits are aggregated across various social groups by adding up the 'willingness to pay' for benefits or 'willingness to accept' as compensation for losses. Although a standard cost benefit analysis does not account for distributional concerns, sometimes, low income groups' benefits or costs are assigned higher weights to account for social concerns. Since CBA involves aggregation over a period of time, future benefits and costs are discounted to derive the present values. Inflation is taken care of by considering constant price estimates. An example will illustrate the central idea of ECBA. Consider the development of a wilderness area. Let the present value of development benefits be denoted by BN, that of development costs by CO and the discount rate by 'r'. When we ignore environmental impacts, the Net Present Value 'NPV' of the project is given by:

$$NPV = \sum_{t=0}^{t-T} \frac{(BN_t - CO_t)}{(1+r)^t} - \sum_{0}^{T} \frac{BN_t}{(1+r)^t} - \sum_{0}^{T} \frac{CO_t}{(1+r)^t} = \text{BN} - \text{CO} \quad ....(14.6)$$

After accounting for environmental impacts, the NPV is given by:

$$NPV = BN - CO - EC \quad ....(14.7)$$

where, EC represents environmental cost. It is taken as the present value of the stream of the net value of the environmental impact of the project over its lifetime. The project should be allowed to go ahead if the NPV is positive. That is, if:

$$\text{BN} - \text{CO} > \text{EC} \quad ....(14.8)$$

14.6.1 Application of ECBA

Two types of environmental 'cost benefit analysis' (CBA) can be distinguished on the basis of the timing of conducting analysis: *Ex-ante* CBA is undertaken prior to the implementation of the project to find out an optimal alternative and *Ex-post* CBA undertaken after the project has been implemented to examine the net benefits realized from the project. Ideally, a cost benefit analysis should be conducted ex-ante because many a times, environmental damages cannot be repaired.

There are various stages of ECBA. These are: (i) defining the problem (e.g. identification of beneficiaries and losers, defining the time horizon); (ii) identifying the project's physical impacts; (iii) valuing the impacts; (iv) discounting the cost-benefit flows (with an appropriate discount rate selected); (v) selecting the project to be implemented on the basis of a net present value criterion; and (vi) sensitivity analysis (e.g. checking how NPV changes with the choice of various discount rates). Policy makers typically conduct the first stage, whereas experts in geology, ecology and other sciences conduct the second stage. Economists are primarily involved in stages three to six. Essentially, the success and reliability of ECBA depends on the monetary evaluation of the impact on the environment. The distributional implication of the project is another area which requires policy attention.

14.6.2 Valuation of Environment

If there is significant damage to environmental assets, the 'cost' component in ECBA should include the 'Total Economic Value' (TEV) of the depreciated environmental asset. Correspondingly, if a project improves environmental quality, the 'benefit' component in ECBA should record the rise in TEV of the environmental asset. Basically, TEV encompasses both the use value and the non-use value of the environment. Use value is the benefit which is derived from using the environment. Some natural resources have direct use value (e.g. crude oil, timber from forests, medicinal herbs). Recreational fishing, hunting, swimming, and other such activities also provide use values. Use values may be indirect as in case of individuals watching television shows on wildlife for recreation. Some ecosystem services such as waste assimilation, water purification, etc. also provide indirect use values. Forests, for example, directly provide timber but there are indirect use values of forests arising from prevention of soil erosion, carbon storage, etc.

Non-use value is obtained by aggregating option value, bequest value and existence value. Environmental goods and services are valued for their future benefits given the uncertainty of future supply. Option value may be conceived as insurance premium which the individuals are willing to pay in order to ensure availability of some environmental goods and services in future. There is a lack of consensus on whether option value should be placed in 'use value' or 'non-use value' category. Bequest value is the value of satisfaction derived from preserving the natural environment for successive generations. For instance, we may be willing to pay to reduce green house gas emissions so that future generations do not suffer from adverse consequences of global warming. Existence value is the satisfaction derived from the simple knowledge that a particular environmental good exists. For instance, an individual may derive satisfaction from knowing that endangered species exist and their protection from extinction is necessary even though he may never have an opportunity to see that species or derive any benefit from it.

Three standard environmental valuation methods are discussed in literature: Stated Preference Method, Revealed Preference Method and Benefit Transfer Method. Under the Stated Preference Method, people are directly asked to place a monetary value on the environmental good or service. The Revealed Preference Method follows an indirect approach as individuals' willingness to pay is inferred from their observed behaviour rather than direct questioning. Revealed Preference Method can be either market-based or surrogate market based. Market based method is based on directly observed market values. For instance, the value of fertile soil which is a natural asset cannot be observed directly. But using a production function approach, one can calculate the loss in output due to decline in soil fertility, by considering soil as an input in production. This procedure helps to deduce the value of fertile soil in terms of output loss. In some cases, non-market environmental goods and services have surrogate markets i.e. markets for a related good or service. Such markets can reveal the individuals' indirect preference for a non-market environmental good. Travel Cost Method and Hedonic Pricing Method are two methods which use surrogate markets for valuation of some environmental goods or services. For instance, in the Travel Cost Method, household expenditure and time spent in travelling to a recreational park is taken as a measure of willingness to pay for the recreational benefit derived from the park. Likewise, in the Hedonic Pricing Method, value of clean air is deduced from the extra premium that people are willing to pay to stay in a house located in greener areas free from pollution. All else being equal, property prices will be higher in cleaner and greener localities.

Sometimes using market based or surrogate market based methods may not be possible. In such cases, Stated Preference Method is employed which uses non-market based methods. For instance, individuals may be directly asked to reveal their willingness to pay for preserving a particular species. Such a method is known as *Contingent Valuation Method* (CVM). This is a widely used stated preference technique. In CVM, the respondents are directly asked how much they are willing to pay for environmental goods. Assuming a hypothetical situation, the compensation they are willing to accept for losses in environmental quality is ascertained by direct enquiry. While other techniques capture only the use values (direct and indirect), CVM captures both the use and the non-use values of the environment, at least, in principle. However, CVM may be subject to deficiencies such as improper questionnaire design and respondents' bias. Another Stated Preference Method is *Choice Modelling* wherein respondents are required to choose the most preferred alternative from a set containing a minimum of two options. At least one option in the set should be the current situation. Respondents are required to rank the various options. Such a method permits the respondents to analyze the tradeoffs between various alternatives.

Another method used to value environment is the Benefit Transfer Method. This method uses the already existing estimates from completed studies on some other issue or location. It then assigns values for similar environmental changes. Such a method is generally undertaken due to time and resource constraints on fresh evaluation. Since additional assumptions have to be made in applying the results of past studies, this approach is considered subjective.

The valuation techniques discussed above are all applicable and widely used in ECBA. However, they are subject to a few limitations. While the Stated Preference Method is subjective, the Revealed Preference Method is though more objective, its scope for valuing environment is limited as it is applicable to situations where individuals are already making payments for environmental goods one way or the other. The Revealed Preference Method cannot be used for evaluation of non-use values of the environment (e.g. preservation of endangered species). Typically, the Stated Preference Method has been used more in ECBA. The CVM can be used to estimate the use values as well as the option, bequest and the existence values. However, this method is also criticized as it generates hypothetical price estimates not reflecting the true willingness to pay. But due to lack of alternative methods, CVM and other Stated Preference Methods are widely used in ECBA.

14.6.3 Limitations of ECBA

Sometimes environmental degradation can be far beyond repair. Many ecosystem services (like the ozone layer) simply cannot be substituted by physical capital. Degradation of such critical natural capital poses a threat to survival of mankind. ECBA ignores these critical and non-substitutable natural capital assets. Thus, utility losses reported by a typical ECBA may not be substantial enough to stop a project which poses a threat to human survival. Such projects should be analyzed separately outside the confines of a cost benefit analysis. The choice of the discount rate is very subjective. Sometimes, discounting transforms future benefits and costs into very small present values which may not appear to be very significant countering the very idea of intergenerational equity. The discount rate must therefore be chosen judiciously.

Some environmental economists contend that there is a lot of ambiguity and uncertainty in the valuation of the environment, especially the ecosystem services as the value of environment cannot be perfectly quantified and measured by the yardstick of money. It is possible that many ecological connections get missed out while conducting such valuation exercises. Nevertheless, attaching no value is as good as attaching a value of 'zero'. Knowing that our environment is priceless, it is inappropriate to attach a 'zero' value for it. Evaluating the costs and benefits of a project from a societal as well environmental perspective is therefore crucial for achieving greener growth.

Check Your Progress 3 (answer the questions in about 100 words within the space given)

1. Why is it particularly important for developing countries to adopt environmentally accountable SNA? In this context, how is EDP helpful?

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2. What is ECBA? Illustrate the central idea behind ECBA by means of an example.

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3. State the different stages of ECBA. Distinguish between Ex-ante CBA and Ex-post CBA.

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4. Distinguish between direct use-value and indirect use-value of a natural resource? Illustrate by the help of an example.

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5. What are 'surrogate markets'? Which two methods use the concept of surrogate markets to estimate the value of certain environmental goods/services?

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14.7 LET US SUM UP

There is a popular saying: 'what can't be measured, can't be managed'. This maxim applies very well in case of environmental resources. In the context of environmental challenges such as global warming and depletion of natural capital, we need a suitable measure of 'environmentally sustainable growth'. Green accounting provides such a measure. Although implementation of green accounting is challenging and subject to data limitations, it is not impossible. Against this background, the unit has discussed the existing or conventional system of national accounting, identifying its shortcomings and the requisite modifications in order to make it environmentally accountable. Two methods that have been evolved for this viz. SEEA and ENRAP are explained. The usefulness of environmental accounting and the method of ECBA to forestall and compensate environmental impact are discussed.

14.8 KEY WORDS

Carbon Sequestration : Is the process of capturing CO_2 from the atmosphere and putting it into long term storage. The goal is to reduce the effects of global warming and climate change.

Ecological Footprint : Measures human impact on the environment. It is the sum of cropland, forest, grazing land and fishing grounds required for production of food, fiber and timber, etc. for human consumption and absorption of wastes.

Natural Capital : Refers to stock of natural assets like air, soil, water, forest, biodiversity, etc.

Non-Cultivated Biological Resources : Consist of animals, birds, fish and plants that yield both once-only and repeat products over which ownership rights are enforced but for which natural growth or regeneration is not under the direct control, responsibility and management of institutional units.

Pollution Taxes	Are taxes on amount of pollution or on goods whose usage increases amount of pollution.
Stewardship	Are ethics encouraging resource management in a responsible manner.
Shadow Price	In the absence of market value of undesirable products such as pollution/environmental degradation, shadow price can be calculated. Shadow price refers to net change in social welfare due to a unit change in the supply of a good. For instance, shadow price of wilderness is the change in social welfare caused by one (measurement) unit change in wilderness.

14.9 SUGGESTED REFERENCES FOR FURTHER READING

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14.10 ANSWERS/HINTS TO CYP EXERCISES

Check Your Progress 1

1) See 14.2 and answer.

2) See 14.2 and answer.

3) See 14.2 and answer.

4) See 14.2 and answer

5) See 14.2 and answer.

6) See 14.2 and answer.

7) See 14.3 and answer.

8) See 14.3 and answer.

Check Your Progress 2

1) See 14.4 and answer.
2) See 14.4 and answer.
3) See 14.4.1 and answer.
4) See 14.4.2 and answer.
5) See 14.4.3 and answer.
6) See 14.4.4 and answer.
7) See 14.4.4 and answer.

Check Your Progress 3

1) See 14.5 and answer.
2) See 14.6 and answer.
3) See 14.6.1 and answer.
4) See 14.6.2 and answer.
5) See 14.6.2 and answer.

UNIT 15 COMMON PROPERTY RESOURCES MANAGEMENT

Structure

15.0 Objectives

15.1 Introduction

15.2 Characteristics of Common Property Resources (CPRs)

- 15.2.1 Problem of Commons
- 15.2.2 Types of CPRs
- 15.2.3 Role of CPRs in Development

15.3 Theories of CPRs Management

- 15.3.1 CPRs Management Versus Private Property Resource Management
- 15.3.2 Resource Conflict and Cooperation
- 15.3.3 Repeated Interactions – Finite and Infinite Repeated Games
- 15.3.4 Grim Trigger Strategy with Discount Rate

15.4 Field Studies on CPRs Management

- 15.4.1 Management of CPRs in India
- 15.4.2 Management of Global Commons

15.5 Global Environmental Externalities

- 15.5.1 Climate Change
  - 15.5.1.1 Economic Analysis
  - 15.5.1.2 Cost-Benefit Studies
  - 15.5.1.3 Long-Term Environmental Effects
  - 15.5.1.4 Policy Responses

15.6 Let Us Sum Up

15.7 Key Words

15.8 Suggested References for Further Reading

15.9 Answers/Hints to CYP Exercises

15.0 OBJECTIVES

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

- state the characteristics of CPRs;
- describe the role of CPRs in economic development;
- discuss the theories of CPRs in alternative scenarios;
- state the major findings of the field studies on CPRs management;
- outline the practices followed in the management of CPRs in India;
- explain the issues involved in the management of Global Commons; and
- discuss the issue of 'global environmental externalities' with a focus on the measurement of climate change and policies for its abatement.

15.1 INTRODUCTION

Developing countries characterised by large rural economy and high population pressure depend critically on locally available natural resource base (called commons) for their firewood, fodder, grazing cattle, fishing, water for irrigation, etc. Their livelihood depends on the utilisation of common property resources (CPRs) such as rivers, canals, forests, grazing lands, etc. The CPRs help in smoothening the consumption of the poor people by creating an incentive structure for protecting the management of CPRs which is a source of their livelihood. However, CPRs are increasingly exposed to unsustainable exploitation, pollution and conversion to other uses. This aggravates the problems of rural poverty, food security, rural-urban migration and growth of slums in cities.

Hardin (1968) tries to explain the situation of over-exploitation of the CPRs in what he terms as the 'Tragedy of the commons'. In CPRs, individual users' are motivated to maximize their share by harvesting the resource as soon as possible (i.e. before other users do so) leading to unsustainable depletion of the resource. This means, when everybody owns the resource, nobody has the incentive to conserve it for future use and hence each user imposes an external cost on all other users in terms of reduced resource availability. This problem of free-ridership leads to under-investment (relative to the social optimum) in CPRs e.g. lack of fencing, non-maintenance of irrigation systems, failure to replant forests, etc. Further, since management options need to be chosen without the aid of price signals compatible with private property ownership, implementing an economically efficient management system becomes challenging. However, innovative approaches such as rotational irrigation and community forestry have been developed by many countries to get around the problems of free riding leading to the 'tragedy of the commons'.

15.2 CHARACTERISTICS OF COMMON PROPERTY RESOURCES (CPRs)

Common Property Resources (CPRs) represent natural resources as well as man-made resources which are not privately owned by individuals. However, access rules are often well defined, with the property rights vested in the tribes, the village, the clan, user committees, cooperatives, municipality, or the local government. Nobel prize winner Elinor Ostrom noticed that a number of common property regimes are based on self-management by a local community. Common property resources can be usually identified by the following characteristics.

- No member of the community can be excluded (i.e. characteristic of **non-excludability**) from the use of resources. Rather, it is costly to exclude individuals from using CPRs like physical barriers or legal instruments. However, restrictions to entry of outsiders prevail.
- Resource-use is **rival** or subtractive in the sense that benefits consumed by any user would reduce the access or benefit by the other members of the group.
- **Private ownership** (of individual or groups) is absent with well defined community (localised) groups having exclusive joint **user rights** to utilise the CPRs.
- Like in the case of public goods, there is an element of **indivisibility** of the CPRs. Hence, CPRs are also called 'collective goods'.
- CPRs have historically evolved rules and regulations on the use of resources (usually outside the legal framework) and sharing of its benefits restricting their overuse and monitoring the entry by outsiders.

Table 15.1 shows a classificatory framework of four type of goods illustrated for the two important characteristics of rivalry and non-excludability.

Table 15.1: Classification of Goods by Major Attributes of CPRs

Characteristics	Excludable	Non-excludable
Rival	Private Goods (e.g. food, clothing, cars, parking spaces)	CPRs (Common Property Resources) e.g. fish stocks, timber, coal
Non-rival	Club Goods (e.g. cinemas, private parks, satellite television)	Public Goods (e.g. air, national defence)

15.2.1 Problem of Commons

As seen in Table 15.1, CPRs share with public goods the difficulty of excluding the beneficiaries (i.e. both have the characteristic of non-excludability) and with private goods the attribute of rivalry (i.e. one person's consumption subtracting the availability of goods available to others). Thus, CPRs are vulnerable to **negative externalities (**like problem of congestion or over-crowding, pollution, over-exploitation, etc.) and potential destruction threatening the sustainability. The monitoring costs become high compared to the benefits. Due to this factor, CPRs would face the problem of **moral hazard** i.e. the probability of being caught becomes low and hence the expected penalty happens to be too low for non-compliance. Moreover, **non-enforceability** for inducing positive compliance is another problem since the beneficiaries of CPRs are often from the very poor background and hence even if they are caught, imposing a penalty may not be feasible. Thus, CPRs are associated with three nested social dilemmas: (i) multiple appropriators harvesting from a single common property leading to the 'tragedy of the commons'; (ii) spending time and effort to create a new set of rules for compliance which will not work (as for them to work, they must have rules imposed upon them from outside as normally rule enforcement is treated as an exogenous variable rather than something that participants themselves undertake); and (iii) since monitoring and sanctioning are costly activities, there is a public good dilemma.

15.2.2 Types of Common Property Resources

Depending on the rights that users hold, the CPRs are broadly classified as: (i) common property; (ii) open access; (iii) state property; and (iv) private property. Baland and Platteau (1996) make a distinction between *regulated common property* (where a set of rules governing resource utilisation are in place) and *unregulated common property* (where no rules limit utilisation). Unregulated common property resources are protected only by community membership restrictions with no conservation rules existing or enforced.

Open access resources denote lack of exclusive ownership and control on entry of new users. Examples include marine resources in international water, air, atmosphere and open space. Since access for potential users to exploit open access resources is free and unregulated, they are highly prone to over-use and degradation. Examples include overfishing in international waters, difficulty in regulating trans-boundary air pollution, etc. *State property resources* are those which formally come under state's ownership for which state would enforce both access and conservation rules. When government fails to enforce rules it may become *de facto* open access. Many tropical forests are state property which in many cases degenerate into open access as encroachment, settlement and illegal logging go unchecked. *Private property* refers to exclusive right vested in the private individual. The ideal or perfect type of private property rights are those which are complete, secure, transferrable and provide the holder with right of possession, transfer, use and change including destruction of the asset.

Resource domains that do not fall within the jurisdiction of any one particular country, and to which all nations have access, are referred to as *Global Commons.* International law recognises four global commons viz.: (i) the High Seas (waters located outside each country's 200-mile exclusive economic zone), (ii) the Atmosphere, (iii) the Antarctica and (iv) the Outer Space. Their resource domains are guided by the principle of the common heritage of mankind. Resources of interest or value to the welfare of the community of nations – such as tropical rain forests and biodiversity - have lately been included among the traditional set of global commons.

The key challenge of the global commons is the design of governance structures and management systems which can address the complexity of multiple national/sub-national public and private interests to avoid the *classic tragedy of commons*.

15.2.3 Role of CPRs in Development

Region specific studies in India on CPRs suggest that they play diverse roles in relation to rural livelihoods. These studies have viewed CPRs as resources which contribute to the economic well-being and hence assist in augmenting and framing policies for removal of poverty. In particular, the following two aspects on the relevance of CPRs have received attention:

1. CPRs are acting as safety nets especially in times of agricultural crises. CPRs provide supplementary rural livelihood in addition to primary source of rural livelihood e.g. agricultural income.

2. There is complementarity between agricultural output and the use of CPRs as inputs in agriculture. A large part of agricultural inputs such as fodder, grazing grounds and irrigation water are made available through the conservation of common property resources. By this contention, there exists a complementarity between agricultural development and the conservation of CPRs.

In light of the above, CPRs need to be managed for efficiency and sustainability. From the point of management efficiency, there are scale advantages in evolving CPR regimes. Pooling human power and indigenous and modern technical knowledge that go with the CPRs management leads to economies of scale in its productive use. Equally relevant is the case of higher carrying capacity of the CPRs. This becomes clear if we consider three alternative management regimes: private, CPRs and open access. Figure 15.1 considers land productivity as an indicator of efficiency.

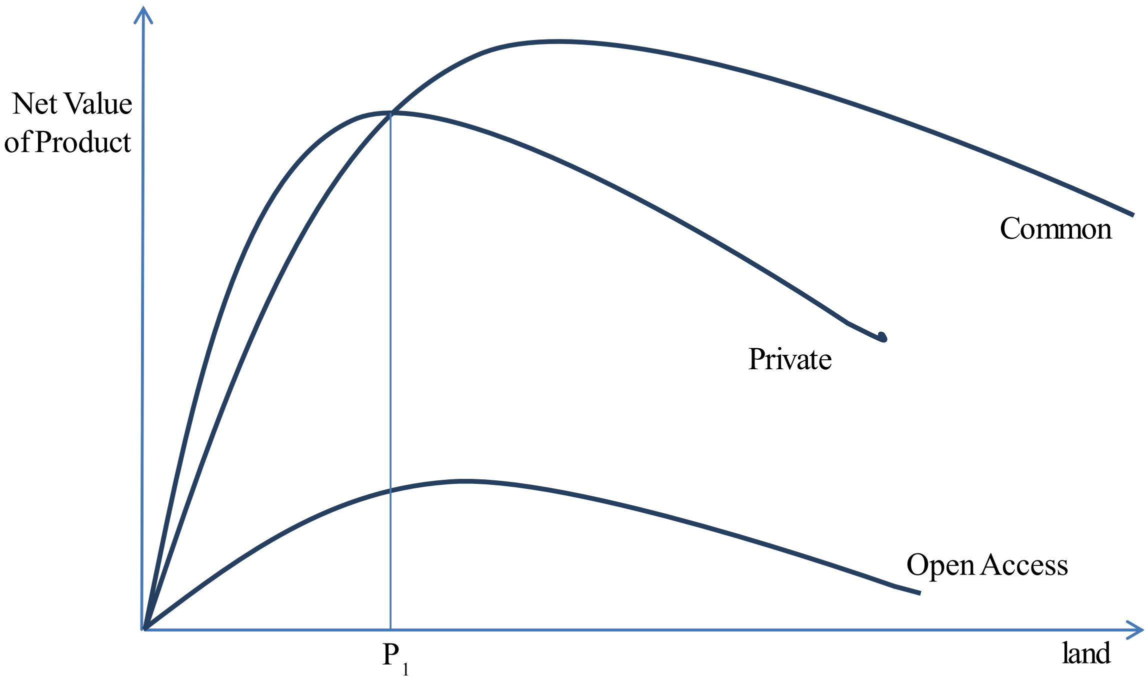

Figure 15.1: Efficiency of Land Use and Property Right Regime

Up to level P_1, private ownership is preferable. However, beyond P_1, in terms of its carrying capacity, CPRs management has an edge over private management. Open access, in any case, is a fall out of the failure of CPRs resource or even private resource management and is least efficient. The carrying capacity of private management, defined as the maximum productivity, is also much lower than that under the CPRs regime. Thus, efficient management of CPRs has both the developmental and the environmental sides of its advantages to the community.

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

1) Due to which particular characteristic of CPRs, they are also called as 'collective goods'?

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2) State the three social dilemmas of CPRs.

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3) Which are the four global commons recognised by international law?

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4) What argument is generally made on conserving CPRs linking it to rural livelihood on the one hand and rural development on the other?

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15.3 THEORIES OF COMMON PROPERTY RESOURCES

We first consider the simple instance of a common grazing land to compare the relative efficiency of CPRs management vis-a-vis the private property rights management. We then consider some instances where resource conflict and cooperation issue arises in CPRs.

15.3.1 CPRs Management Versus Private Property Resource Management

Let us consider the instance of a grazing land, which yields the output of fodder, with two alternative management options viz. private and common property regime (Figure 15.2). Let OX_C represent the value of the 'marginal fodder product' under the CPRs management, at different levels of use of grassland resource. Similarly, let OX_P represent the same under the private property right (PPR) management (Figure 15.2). The level of grassland use up to R_X yields higher marginal returns from private management. Beyond that level (due to factors like crowding of resource users, indivisibility of resources, competition and uncertainty), the net 'marginal private productivity' of the grazing land begins its rapid decline.

For the resource management under CPR beyond R_X, there is higher marginal productivity on the curve OX_C which rises through the point E to A and then decline from A to B with the decline becoming steeper through the points B to C. Let OY_C represent the marginal resource cost (of incremental grassland) under the CPR regime and OY_P under the PPR regime. There is an implicit assumption here that the cost of rearing under CPR are generally lower, but both are increasing straight lines. Thus, under the net benefit maximising rule, the efficient level of CPR is R_C and under the PPR regime R_P (the point of equality between the marginal productivity and the marginal resource cost). The exploitation of resources is higher under CPR management (as also the output fodder) and so also are the net benefits. This result is generally misinterpreted by saying that a CPR regime uses more resources and hence can lead to higher rates of degradation. If better collective and community management rules can be introduced, the difference between the private marginal costs and CPR marginal cost can be saved by the community as rental and invested for future benefits and/or resource development. In the event that the resource is to be treated as an open access resource, the option open for the resource users is to equate the total benefit with total resource cost. This is the point R_O, when all the net positive benefit up to R_C [area between marginal productivity and marginal resource costs under a CPR regime, shown by the light shaded area)] are neutralised by the negative net benefits from using the resources between R_C and R_O

(area between marginal resource cost and marginal productivity curves). The main findings from this theoretical model are, therefore, that: (i) CPR regime allows the management of large resources (such as fishing lake, grazing lands, protected forests) having

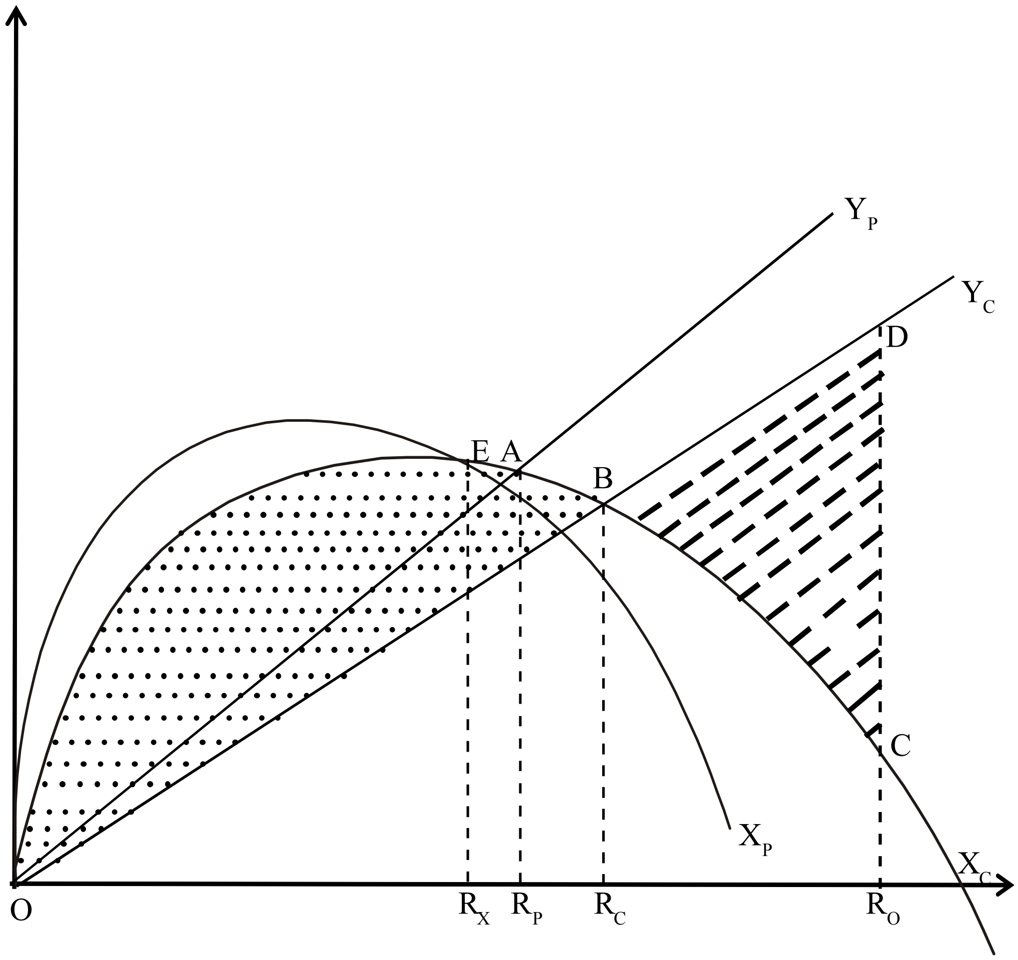

Figure 15.2: Grazing Land Resources

the characteristic of indivisibility thus allowing for scale exploitation; (ii) the total net benefits from CPRs regimes are higher than those under private management, as the usage of CPRs itself is higher than that under a private regime; (iii) CPRs regimes are superior to open access resource management (viewed from the point of view of sustainability); and (iv) CPRs management keeps the exploitation of resources below the maximum sustainable yield rates. Due to these theoretical features, CPRs management provide more benefits to the people dependent on such resources. However, if costs of governance, enforcement and policing under a CPRs regime becomes higher than the transaction costs under a private regime, or when CPRs management fails to take note of market signals such as prices, the management of the resource under a CPRs regime may become inefficient and may even collapse.

15.3.2 Resource Conflict and Cooperation

To analyse the strategic interaction between agents or the stakeholders utilising the same finite CPR, theoretical research in CPR management applies non-cooperative game theory. Often, the decision making or the game concerning the CPR management would deal with the 'dilemma of resource conservation'. In the 'two person one shot' strategic game, literature focuses on the application of prisoner's dilemma (PD), in which defection (non-cooperative behaviour) is the dominant strategy. This is also the theoretical underpinning of the Hardin's 'Tragedy of the Commons' and Olson's 'Logic of Collective Action'. The PD game is illustrated in Table 15.2, where P stands for participation (or cooperative strategy) and D stands for defection (or non-cooperative play).

Table 15.2: P-D Resource Conservation Game

Villager 1 (rows) / Villager 2 (columns)

P/D	Participate (P)	Defect (D)
Participate (P)	(s, s) = (7, 7)	(v, r) = (0, 10)
Defect (D)	(r, v) = (10, 0)	(t, t) = (4, 4)

Consider a village pasture where two local villagers graze their cattle. A villager can graze more cattle with the same effort and cost, but beyond a certain level it is unsustainable for the commons. So, each of the villager has two options to decide i.e. whether to participate (P) or to defect (D). Let the villager 1's action be represented horizontally and that of the villager 2 vertically. There are 4 possible outcomes of the decision making depending upon the different actions of each villager. The payoffs of the villager 1 and 2 are shown respectively in the parenthesis of each cell. If both the villagers maintain a sustainable number of cattle (i.e. they are extracting the resources in a restrained manner participating in the conservation of the commons), then their payoff is (s, s) = (7, 7). But if any of them defects from participation (given that the other one participates), the defector's payoff increases to 10 and the one who is participating gets 0 i.e. (p, d) = (v, r) = (0, 10) or (d, p) = (r, v) = (10, 0). So there is always an incentive among the villagers to free-ride or overgraze (defect). Thus mutual defection or free riding (D, D) = (t, t) becomes the *dominant strategy equilibrium where each villager gets a payoff of 4 only.* The strategy of defection for each of the villager dominates the strategy of participation irrespective of the other players choice of action (or participation is dominated by the strategy defection for each of the villager).This sort of outcome is described by Mancur Olson (1965) as - *individual rationality producing collective irrationality.*

Here the cooperation is not sustainable. Both the villagers face a credible threat that if he participates, and his rival defects, it may push him down to zero payoff. This mutual threat pushes them to play safe by choosing the defect (D, D). So the outcome is the unique pure strategy, (D, D), with payoff = (t, t) = (4, 4). This is the mutually best response strategy or *Nash equilibrium* although it is not *social/Pareto optimal*. Hence lack of institutional control may lead the individuals to over-exploit the natural resource base. So long as there are multiple users competing for the resource, and pay-off structure follows the inequality r > s > t > v, extraction by one creates negative externalities on others causing Hardin's *tragedy of the commons.* Such over-exploitation can be prevented by strong authority (i.e. the top-down approach of 'governing the commons') with long term vision for resource management i.e. with the state penalising the private parties for the non-conservation of CPRs. The top-down approach can prevent CPR degradation if the expected penalty for free riding exceeds any benefits. This can be illustrated as follows.

Consider a violator is charged with a fine *F* with the probability that he can be caught as *m*. Thus, his expected fine is: $mF + (1- m)\ 0 = f$. If *f* is such that $(r – f) < s$, Nash equilibrium will be (P, P) = (7, 7). Further, if (t – f) < v, the PD game will have unique Nash equilibrium (P, P). If $f = 4$, this changes the payoff of the PD game as reflected in Table 15.3.

Table 15.3: PD Illustrated with a Fine (f)

		Villager 2	
		Participate (P)	**Defect (D)**
Villager 1	**Participate (P)**	(s, s) = (7, 7) (**NE**)	(v, r - f) = (1, 6)
	Defect (D)	(r - f, v) = (6, 1)	(t - f, t - f) = (0, 0)

15.3.3 Repeated Interactions – Finite and Infinite Repeated Games

The problem in applying the prisoners' dilemma kind of game to the use of natural resources is that there is a credible threat of free riding by way of the people's participation in an unsustainable manner. But if we take a framework of repeated interactions for the PD game (i.e. with same players, same strategies and payoffs, the game is repeated period after period) in common property benefit extraction, the cooperation is sustainable for the infinitely repeated game though not for the finite repeated game. Clearly, in a finitely repeated game (where the terminating period is certain, however long it may be,) the solution concept for the Subgame-perfect-Nash-equilibrium (SpNe) can be worked out through backward induction in which mutual non-cooperation or (Defection, Defection) is the unique equilibrium outcome.

Consider a PD game under finite repeated interactions for T periods (T is finite). For the backward induction, consider the last period i.e. T^{th} period. Since there is no future after the T^{th} period, no punishment threat will be credible and hence the promise to play (P, P) in the T^{th} period is unlikely. Hence, unconditional defection or free riding is the dominant move of both the players in the last period. So the last period game can be treated in isolation like the stage game of Table 15.2. Since the players know that they can't punish the others for defection, the last period game is fixed at (D, D), which is the Nash equilibrium of the one-shot game. The game is fixed for the penultimate period (T-1) also at (D, D). Hence the promises of cooperation is non-credible in the previous period and so forth. Hence, (D, D) is SpNe.

However, if the game is repeated for infinite period it opens the possibility of conditional cooperation and punishment. In such kind of a game, the last period (or the terminating period) is not certain and hence backward induction will not work for sub-game perfection. The punishment strategy for defection thus becomes credible in an infinitely repeated game or game with uncertain number of periods.

15.3.4 Grim Trigger Strategy with Discount Rate

In a *grim trigger strategy* of punishment, where cooperation is rewarded with cooperation, a single defection from any one of the player will trigger defection forever. The idea here is that players may be deterred from exploiting the short term advantage by a threat of punishment which reduces their long term payoff. Thus, a move of any t^{th} period is conditioned by all the outcomes of the (t-1) periods. We assume that: (i) players will start playing at (P, P); (ii) thereafter in period 'n', players choose the action that the other players had chosen in period (n – 1); and (iii) δ is the discount rate ($0 \leq \delta \leq 1$, *and* $\delta \rightarrow 1$) meaning that the player is increasingly more patient. Considering the discounted value of the stream of payoff from the strategy (C, C) [i.e. (Cooperation, Cooperation)], the present discounted value of payoff will be:

$PDVc_i = s + s\,\delta + s\,\delta^2 + s\,\delta^3 + s\,\delta^4 + + + \ldots\ldots\ldots\ldots\ldots\ldots\ldots.$

$= s\,(1 + \delta + \delta^2 + \delta^3 + \delta^4 + + + \ldots\ldots\ldots\ldots$

$= \frac{s}{(1-\delta)}$

In case of defection from the rival player, the present discounted value of payoff will be:

$PDV_{Di} = r + \delta\,t + \delta^2\,t + \delta^3\,t + \delta^4\,t + \ldots\ldots\ldots$

$= r + \delta\,t\,(\,1 + \delta + \delta^2 + \delta^3 + \ldots\ldots.$

$= r + \frac{\delta\,t}{(1-\delta)}$

The players will play (C, C) forever if: $\frac{s}{(1-\delta)} > r + \frac{\delta\,t}{(1-\delta)}$

Or, $\frac{s-\delta\,t}{(1-\delta)} > r$ *Or* $s - \delta\,t > r\,(1-\delta)$ *Or* $\delta > \frac{r-s}{r-t}$

Assuming the parametric restrictions in payoff structure: r > s > t > v, as in Table 15.2, it follows that $(r - s) < (r - t)$.

Hence, $\delta^* = \frac{r-s}{r-t}$ is the *Critical Discount factor*. Thus, if $\delta > \delta^*$, cooperation under infinitely repeated PD game can be sustained and the tragedy of commons can be averted. If δ is sufficiently large, it means players are patient and they value their long-term benefit over their short-term gain.

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

1) State the four major findings of the model considered for a comparison of CPRs and PPR managements. Under what circumstances would the CPRs lose their relative efficiency over PPR management?

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2) In a two-person strategic game of two village grazers, what is meant by 'individual rationality producing collective irrationality'?

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3) In the illustration in question 2 above, is the dominant strategy social/Pareto optimal? Explain.

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4) In a repeated game of scarce CPRs, in which of the two cases, finitely repeated or infinitely repeated games, a Subgame Perfect Nash Equilibrium (SpNe) is assured? Why?

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5) Writing the expressions for the 'present discounted value of payoff' for the two strategic games of cooperation by both the players [i.e. (c, c)] and that of the defection of the rival player, state the conditions under which the players will play the game (c, c) forever?

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15.4 FIELD STUDIES ON CPRs MANAGEMENT

Generally, not all CPRs display successful management, nor are they cases of general failure. With substantial variation across time and space in the ability of the villagers to manage their collective resources, some stylized facts that emerge from the case studies are as follows.

1. Smaller groups and small villages are more likely to manage CPRs efficiently.

2. Communities deter members from breaking rules by using fines (imposed in cash or kind), moral persuasion, social exclusion of offenders, etc.

3. Cooperation and collective action for resource management is the more likely outcome when there is larger potential gain. This is likely when the CPRs generate a substantial share of income to the community and potential losses from over-use and resource degradation are large.

4. Wrong guidance, outside intervention, may be by the state, tend to break down the traditional management systems. Thus, when colonial and independent governments have nationalized natural resources, it has often led to the collapse of existing CPR management system. The failure is partly due to the lack of detailed local information, and failure to involve the local stakeholders, both factors together making monitoring and enforcement prohibitively costly and difficult. Policymakers have paid insufficient attention to local institutional, cultural, technical and natural environment. In some villages, external intervention from NGOs and others have tried to involve larger local labour role in the maintenance of common land and water resources.

5. There is a complex relationship between CPR and equity. The impact of collective action for reducing inequality at community scale is ambiguous. In general, some

degree of trust among the community members is necessary for inducing collective action and compliance with rules. Historical or otherwise inequality among the users, in income and production capacity, may induce distrust leading to conflict and reluctance to abide by agreements. For instance, some regions in India have long history of conflict between high and low caste villagers. There are examples of how powerful/vocal villagers misappropriated CPR's control by supposedly democratic forest councils to get undue use rights to the detriment of the weaker sections (e.g. Ribot, 1995). Nugent (1993) notes that local organisations and institutions can suffer from the same problems of rent seeking leading to inefficiency that quite often plague politics at the national level.

6. There are also findings to demonstrate that inequality sometimes increases the likelihood of collective actions (e.g. Jodha, 1992). They indicate that the poor rely on CPRs for a larger share of their income than the wealthy, contributing to decreasing income inequality. The reason for this is that the poor have lower opportunity costs of time and therefore readily work in CPRs. In rural parts of Sub Saharan Africa, common property farm lands, pastures and other resources often provide social security and substitute for missing insurance markets.

The above findings bring out that resources under common property serve vital economic functions. Many CPRs display lower transaction costs. CPR's role as an insurance substitute often depends on secure and easy access to geographically dispersed resources. Herders in the arid and semi arid tropics thus rely on common property to a very large extent because of the large spatial variability in rainfall, water, and pasture, which makes it critical to have access to very large areas. Some authors (e.g. Nugent and Sanchez, 1993) argue that tribal institutions can play a larger role as compared to agricultural societies in fulfilling crucial CPR management functions.

15.4.1 Management of CPRs in India

In pre-British India, a very large part of the country's natural resources were freely available to the rural population. These resources were largely under the control of local communities. Gradually, with the extension of state control over these resources and the resultant decay of community management system, CPRs available to the villagers declined substantially over the years. Today, in almost all parts of the country, the villagers have a legal right of access only to some specific categories of land and water resources. Nevertheless, it is widely held that CPRs still play an important role in the life and economy of the rural population. In this context, the present section provides certain basic statistics on the size of CPRs, type of benefits derived from CPRs, proportion of households making use of CPRs, etc.

- Common pool land resources are estimated to be about 70 million hectares in the major states of India (Chopra and Gulati, 2001). Of this, forest based common pool resources are estimated to be 25.1 million hectares. The rest of the common pool resources are under the ownership of local bodies of different kinds and some of it under private ownership but open to periodic common access.

- In the eighties, when many were lamenting the failure of land reform in the Indian countryside, Jodha's (1986) work on CPRs raised a different type of question, namely who benefits from land reform and who loses out. His study pointed to three main results: (i) privatisation for the most part was captured by the rural rich with the land the poor obtained from privatisation being often of poorer quality; (ii) privatisation of CPRs led to the loss of major income from CPRs; and (iii) the poor were the bigger losers in terms of loss of income.

- Using macro-level data, Chopra et al. (1990) used a nine-fold land use classification data to estimate the total area of CPRs. Other than current fallow, their classification of CPRs included cultivable waste, pastures, and protected and unclassified forests. Based on this classification, they estimated that 21.6 percent of all land in India (1980–81 figures) were CPRs with the rider that this estimate might be slightly high given that not all protected forests are CPRs. The study also highlighted that CPRs are steadily declining in extent and quality, a point that is important both for the sustainability of CPR dependent livelihoods and the natural resources themselves. Another important point is that the non-poor also benefit from CPRs.

- Some studies, have argued that while the poor benefit more in relative terms, the rich benefit more in absolute terms (Nadkarni et al. 1989; Pasha, 1992; etc.). Furthermore, there is evidence that CPRs are often captured by the rich or allocated in ways that privilege the needs of the rich (Karanth, 1992).

- The economic importance of CPRs, as a proportion of total assets, ranges widely across ecological zones. In India, they are most prominent in arid regions, mountainous regions and un-irrigated regions and least prominent in humid region and river valleys (Agarwal and Narain, 1989). The rationale behind this is based on the mutual desire to pool risks. Woodlands, for example, are spatially non homogenous ecosystems. In some year one group of plants bear fruits in one part of a woodland, in another year some other group does in some other part. Relative to mean output, fluctuations could be presumed to be larger in arid region, mountainous region and un-irrigated areas. If a woodland was to be divided into private patches, each household will face a greater risk than it would under community ownership. The reduction in individual household's risk owing to community ownership may be small. But as average incomes are very low in Indian villages, household's benefits from community ownership are large if woodlands are communally owned.

Three of the most important CPRs management practices successfully running are: (i) Joint Forest Management (JFM) – an illustration of government and communities working together, with communities having a major role; (ii) Watershed Development – where the irrigation or soil conservation department joined hands with the village communities, but with the government playing a major role; (iii) Sacred Groves – where traditionally only the village communities are involved, without any involvement of the government.

15.4.2 Management of Global Commons

There are obvious differences in the scale of both the resources and the number of users at the local versus the global level. There are also differences in the shared culture and expectations of resource users i.e. while the users of localized commons tend to be more homogeneous, those of global commons are more heterogeneous. Moreover, many of the global commons are non-renewable on human time scales and, therefore, resource degradation is more likely to be the result of unintended consequences (i.e. not immediately observed or easily understood). Due to these dimensions, our planet is facing critical environmental challenges like climate change and global warming, depletion of the Ozone layer, rapid environmental degradation in the Antarctica, etc. From a longer time perspective, the carbon dioxide emissions that drive climate change continue to do so for at least a millennium after they enter the atmosphere with some of the species extinctions lasting forever. In addition, the doctrine of *mare liberum* (free sea for everyone) allows for the dumping of wastes and over-fishing in the high seas. In light of this, with no effective laws or policies to control and regulate such practices, the trends are likely to worsen, negatively impacting the capacity of 'global commons' to provide the ecosystem services for human well-being. Such a trend of environmental degradation is already taking its toll on sustainable development and poverty alleviation. More importantly, since there are significant differences in the cost, benefits and interests at the global level, there are also significant differences in the externalities between the uses of local CPRs and the global commons.

The international community has adopted a number of conventions and treaties to govern the global commons. These include: (i) the United Nations Convention on the Law of the Sea (UNCLOS) of 1982; (ii) instruments governed by the International Maritime Organization; (iii) the UNEP's Regional Seas Conventions (to govern the high seas); (iv) the Antarctic Treaty System (ATS) to ensure the protection of the Antarctica fauna and flora; etc. A multitude of international environmental treaties administer and protect the atmosphere and deal with the air pollution and atmospheric degradation. Despite the enactment of several laws and the signing up of treaties, several gaps and challenges exist. For instance, a major legacy of the Law of the Sea treaty process is the assertion by the Group of 77 developing nations that the deep seabed, and minerals contained there, are the 'common heritage of mankind'. It logically follows that the profits from any mining of the deep seabed must be shared with all countries. Thus far, it has not proved cost-effective to mine the deep seabed. Also, the United States has not accepted the 'common heritage of mankind' principle as applied to the deep seabed. This is an area of international environmental law that is still evolving. Likewise, Antarctica which is the vast fifth largest continent covered almost entirely by ice, represents about 90 percent of the world's ice and 68 percent of the world's fresh water. Therefore, beyond its role as home to many of the world's most exploited species (e.g. seals, whales and certain fish), Antarctica exerts a dominant influence on the world's climate. Before 1959, the absence of a common international regime to conserve Antarctica's resources led to the decimation of seals and whales in the Antarctic Ocean. Since 1957–58, the International Geophysical Year, Antarctica has been used primarily as a base for scientific research. The 1958 Antarctica Treaty did not focus on issues relating to environmental protection or economic development. Natural resource development, however, is now a central issue in the debate over how to manage Antarctica. First, there is an increased interest in Antarctica's marine biological stocks. Second, the Antarctic Ocean is a major habitat for marine mammals in general and whales in particular, and these mammals have become a symbol of international conservation and environmental efforts. These factors have forced the international community to confront concerns that were not at issue when the 1958 treaty was negotiated. To supplement the initial treaty, many subsequent agreements were negotiated to deal with natural resource protection and management in Antarctica. The discovery of possible mineral deposits in Antarctica has since led international cooperative efforts to take a turn for the worse. While state parties met and created the 1988 Convention for the Regulation of Antarctic Mineral Resources Activities (CRAMRA), to date it has not been ratified. Intense opposition from environmentalists has made it extremely unlikely that this mineral exploration convention will ever be ratified. This controversy prompted the creation of a Protocol on Environmental Protection to the Antarctica Treaty in 1991. The 1991 protocol expressly designates Antarctica as a 'natural reserve... devoted to peace and science'. The agreement has established a Committee for Environmental Protection responsible for ensuring the undertaking of 'environmental impact assessments' for scientific projects. The protocol prohibits all mineral activities except those in pursuit of scientific research. This prohibition cannot be reviewed without the unanimous consent of all parties, for 50 years following the ratification of the protocol and after the initial 50- year period it can be changed only by a majority. The most glaring weakness of the protocol is its requirement for ratification by all parties to the original 1958 treaty which has not yet occurred. Considering the extreme controversy surrounding both the initial effort in CRAMRA and the counterbalancing effort in the protocol, it appears unlikely that the protocol will ever be enforced. Antarctica is under the aegis of a fragmented international regulatory scheme that seems to take insufficient account of the potential for vast environmental degradation through mineral resources exploitation.

Developing countries, in particular, face a challenge in undertaking expensive environmental impact assessments as they lack sophisticated technology to carry out the environmental conservation activities. Landlocked developing countries and other geographically disadvantaged countries need to be supported to promote their effective participation in the activities related to ocean fisheries, mining and exploration of global commons, etc. as stipulated in UNCLOS. Lastly, there is growing interest, in particular amongst regional economic and military alliances, on access to the global commons from a trade, security and critical resources perspective. A global governance regime, under the auspices of the UN, will have to ensure that the global commons will be preserved for future generations.

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

1) What do the studies on CPRs management reveal in respect of government's and NGO's role in this regard?

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2) Taken cumulatively, what do the studies on CPRs reveal on the management of common property resources?

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3) In the context of the debate on land reform measures and its success/failure in the 1980s in India, in what way the findings of Jodha's study on CPRs were revealing?

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4) State some of the basic differences between the local CPRs and the Global Commons.

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5) What is the implication of the expensive 'environmental impact assessments' for developing countries under the 1988 UN Convention of CRAMRA?

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15.5 GLOBAL ENVIRONMENTAL EXTERNALITIES

Many environmental pollution problems involve multiple countries. Examples can be acid rain, ozone layer depletion, oil spill in oceans, etc. Global warming is an extremely complex issue where each and every country is involved one way or the other. In all these cases, the relative roles and responsibilities of countries and especially developed and developing countries assume significance because they are in different stages of development and their choice of tradeoffs between environment and development differ. In this context, it is worth recalling the following *principles* of Rio Declaration for international cooperation on environment.

- *Principle 2:* States have…… the sovereign right to exploit their own resources pursuant to their own environmental and development policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states.
- *Principle 6:* The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority.
- *Principle 7:* States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, states have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.
- *Principle 9:* States should cooperate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.
- *Principle 12:* States should cooperate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries so as to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a misguided restriction on international trade.

The common but differentiated responsibilities (CBDR) principle is recognized in multilateral agreements relating to trade (Uruguay Round), ozone depletion (Montreal Protocol), climate change (Framework Convention on Climate Change) and biodiversity (Convention on Biodiversity). There are also special programmes for capacity building and financial support in environmental management for developing countries through agencies such as United Nations Development Programme and United Nations Environment Programme and Global Environment Fund. But there are many debatable issues like the transfer of environmentally sustaining technologies to developing countries on concessional terms, use of environmental standards by certain developed countries as non-tariff barriers, etc.

15.5.1 Climate Change

Climate change refers to human activity induced rise in average surface temperatures on Earth. An overwhelming consensus in scientific understanding maintains that climate change is primarily due to the human use of fossil fuels and land use change. The atmospheric accumulations of long lived greenhouse gases including carbon dioxides trap heat within the atmosphere, causing a range of adverse effects on atmospheric parameters such as temperature and precipitation. This phenomena is holistically called as '*global warming*'. The atmosphere is a global commons with open access to all and economic activities carried out by uncoordinated fragmented individual decision makers have led to accumulated emissions. This is today estimated to be closer to the threshold level and hence posing the threat of dangerous interference with climate system. The challenge is how to manage the fragmented decisions for efficient and sustainable use of the global common.

15.5.1.1 Economic Analysis

How human economic activities are driving climate change and how climate change in turn is likely to impact economic activities through complex ecosystems and economic interactions are under wide scale investigation to help in policy making. Scientists have modelled the effects of a projected doubling of accumulated carbon dioxide equivalent in the Earth's atmosphere. Some of these effects are: (i) loss of land area, including beaches and wetlands, to rise in sea-level; (ii) loss of species and forest area, increased forest fires; (iii) increased water stress due to melt down of glaciers and polar sea caps; (iv) increased costs of space cooling ; (v) health damage and deaths from heat waves and spread of vector borne diseases and malnutrition; (vi) loss of agricultural output and food security; (vii) wide spread migrations; and so on. Some of the beneficial outcomes in short term in selected areas include: (i) increased agricultural production in cold climates, higher primary productivity due to CO_2 enhancement; and (ii) lower heating costs. However, such future scenarios are predictable with varying degrees of certainty. Challenge is to evaluate the costs and benefits of economic impacts over time of such major events with varying levels of uncertainty and decide on policy actions.

15.5.1.2 Cost-Benefit Studies

Since carbon emissions is projected to continuously rise unless otherwise abated, aggressive and immediate policy action with long term impact is required to stabilize, and reduce, the total CO_2 emissions in the coming decades. In performing a cost-benefit analysis, the approach is to weigh the consequences of this projected increase in carbon emissions, in terms of the social costs (damage cost) against cost of mitigation (abatement cost) to stabilize or reduce CO_2 emissions. To lower carbon emissions, there are multiple actions across all economic sectors which could be identified with varying mitigation potential and costs. Studies have shown that mitigation now would cost much less than the value of future damages. It thus makes economic sense to invest in GHG reduction to avoid future damages.

15.5.1.3 Long-Term Environmental Effects

Evaluation of future costs and benefits is made by using a discount rate. The implicit value judgments associated with discounting add to the uncertainties involved in valuing the costs and benefits. This suggests that we should consider some alternative approaches – including techniques that incorporate ecological as well as economic costs and benefits. Two major economic studies dealing with the cost-benefit analysis of climate change have come to very different conclusions about policy. One study, by William Nordhaus, suggest that the optimal policy strategy would be a small reduction in the greenhouse gas emissions requiring some changes in the carbon-based energy path typical of current economic development. In contrast, a study by William Cline recommends 'a worldwide program of aggressive action to limit global warming', including cutting back on total carbon emissions well below the present levels and then freezing them at this lower level with no future increase. The main difference between the two studies is that the Cline study considered the long-term effects using a low discount rate (1.5%) to balance the present and future costs. Thus, even though costs of aggressive action might appear higher than the benefits for several decades, the high potential long-term damages into the future should sway the balance in favour of aggressive action today. While both the Cline and Nordhaus studies used standard economic methodology, Cline's approach gives greater weight to long-term ecological effects which are significant both for their monetary and non-monetary effects. The use of a standard discount rate in the 5-10 percent range has the effect of reducing the present value of significant long-term future damages to relative insignificance. An ecologically oriented argument would therefore be that, stabilization of the global climate, rather than the economic optimization of costs and benefits, should be the goal. However, mere stabilization of the greenhouse gas emissions is not sufficient. Thus, any measure taken to prevent the global climate change will mean re-allocation of investible resources across sectors away from current pattern. This explains the reluctance of governments with myopic goals to take drastic measures to significantly reduce emissions of CO_2 equivalent with longer term impact.

15.5.1.4 Policy Responses

Two general policy responses are used to address the issue of climate change: (i) preventive measures (which tend to lower or mitigate the greenhouse effect); and (ii) adaptive measures (which deal with the consequences of the greenhouse effect trying to minimise their damaging impact). Preventive measures include: (i) reducing the level of emissions by shifting to more energy-efficient technologies, fuel switch, demand reduction, etc.; and (ii) enhancing carbon sinks, forest area and ocean uptake. Adaptive measures are to reduce risk of impacts ranging from (i) ecosystem based or hard solutions like dikes and seawalls to protect against rising sea level, coastal floods and hurricanes; and (ii) economic sector-wise measures like changing cropping calendar/ patterns, seed varieties, etc. in agriculture to insuring weather related losses, preventive health care measures, etc..

The economic approach suggests that under uncertainty, when benefits cannot be ascertained, cost-effective analysis can guide policy measures. Examples of market-based policy tools such as global carbon price, carbon tax and transferable or tradable permits (e.g. carbon permits/certificates, subsidy for low carbon options) are seen as useful alternative mechanisms to manage greenhouse gases strategically. These options are further discussed below.

Carbon Taxes: The release of greenhouse gases into the atmosphere is a clear example of a negative externality which imposes significant costs on a global scale. The market for carbon-based fuels such as coal, oil and natural gas takes into account only the private costs and benefits leading to a market equilibrium that does not correspond to the social optimum. A standard economic policy for internalizing the external costs is a per-unit tax on the pollutant. In other words, a tax called as a **carbon tax** is levied exclusively on the users of carbon-based fossil fuels. Such a tax will raise the price of carbon-based energy sources giving the consumers the incentive to shift to alternative sources. Such a shift may be from a source with higher proportion of carbon-based fuel such as coal to sources with relatively lower carbon content such as natural gas. Although the carbon tax would appear as increase in energy prices to the consumers, clearly, a carbon tax creates an incentive for both producers and consumers to minimise their use of carbon-intensive fuels and help promote the development of alternative technologies.

Tradable Permits: A second policy response to climate change is a system of tradable pollution permits which works as follows. Each nation would be allocated a certain permissible level of carbon emissions with the total number of carbon permits issued being equal to the desired goal of overall reduction target. For instance, if global emissions of carbon are 6 billion tons and the goal is to reduce this by 1 billion, permits for 5 billion tons of emissions would be issued. Such permit allocation would take care of both the national and regional reductions. For instance, under the Kyoto Protocol of 1997, the U.S. agreed to set a goal of cutting its green house gas emissions 7 percent below the 1990 levels by 2008-12, Japan agreed to a 6 percent cut and Europe to a 8 percent cut among themselves. For instance, if the U.S. failed to meet its target, but Europe exceeded its target, the U.S. could purchase permists from Europe. The permits might also be tradable among firms, with countries setting targets for major industrial sectors, and allocating permits accordingly. Firms could then trade among themselves or internationally. Nations and firms could also receive credit for reductions that they help to finance in other countries. For instance, U.S. firms could get credit for installing efficient electric-generating equipment in china, replacing highly polluting coal plants.

From an economic point of view, the advantage of a tradable permit system is that it would encourage the least-cost carbon reduction options to be implemented. Depending on the allocation of permits, it might also mean that developing nations could transform permits into a new export commodity by choosing a non-carbon path for their energy development. They would then be able to sell permits to the industrialized nations having trouble meeting their reduction requirements.

<u>Other Policy Option (Subsidies, Standards, R&D, and Technology Transfer)</u>: Although political considerations may prevent the adoption of sweeping economic policy response to climate change such as carbon taxes or transferable permit systems, there are a variety of other policy measures which have the potential to reduce carbon emissions. These include: (i) shifting subsidies from carbon-based to non-carbon-based fuels; (ii) setting efficiency standards (e.g. Perform, Achieve and Trade mechanism of Bureau of Energy Efficiency of GoI) requiring utilities and major manufacturers to increase their renewable content in power sources (e.g. renewable purchasing power obligation policy of GoI); (iii) encouraging research and development (R&D) expenditures for the commercialization of alternative technologies; and (iv) facilitating technology transfer to developing nations (e.g. CDM mechanism). The future course of energy and global climate change policy will undoubtedly be affected by further scientific evidence and cooperation.

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

1) In respect of trade and environmental issues, what are the three major contentious issues in respect of which there is dispute between developed and developing countries?

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2) What is meant by the term 'global warming'?

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3) In the cost-benefit studies approach, what actions are proposed to be taken by countries to reduce the effect of climate change on global environment externality?

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4) Given the divergent benefits from adopting a higher or lower discount rate for reducing the greenhouse gas emissions in the cost-benefit studies now, what is an ecologically sustainable alternative possible in this regard? Is this proposition adequate?

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5) What are the assumptions on which the outcome of the predicted effects of stabilising the emissions would depend?

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6) What is a 'carbon tax'? What are its social benefits?

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7) Apart from carbon tax and tradable permits, what are the other policy options open for adoption to reduce the environmental externalities?

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15.6 LET US SUM UP

CPRs are both the source of income for the extremely poor and marginalised as well as important to conserve for sustainable development. Managed efficiently, they can meet both these objectives in an optimal manner. Against this background, the unit has dealt with the many challenges that confront the management of CPRs. Besides explaining the theoretical and conceptual aspects involved, the unit has dealt with the various policy options like carbon taxes, tradable permits and subsidies, R& D for cleaner energy sources and technology transfer.

15.7 KEY WORDS

Backstop Technology: Is a new technology producing a close substitute to an exhaustible resource by using relatively abundant production inputs. It renders the reserves of the exhaustible resource obsolete when the average cost of production of the close substitute falls below the spot price of the exhaustible resource. For instance, the technology of harnessing solar energy can be perceived as a backstop technology to oil, coal and natural gas.

Bio-diversity: Global Biodiversity is the variety of different types of life found on Earth and the variations within species. It is a measure of the variety of organisms present in different ecosystems. Biodiversity is not distributed evenly on Earth. It is the richest in the tropics. Marine biodiversity tends to be highest along coasts in the Western Pacific.

Consumption Smoothening: It is the concept used to express the desire of people to have a stable path of consumption.

Dominant Strategy Equilibrium: Dominant strategies are considered as better than other strategies, no matter what other players might do. In game theory, there are two kinds of strategic dominance: a *strictly* dominant strategy and a *weakly* dominant strategy. The former is the strategy which always provides greater utility to a player, no matter what the other player's strategy is. The latter is the strategy which provides at least the same utility for all the other player's strategies, and strictly greater for some strategy. A dominant strategy equilibrium is reached when each player chooses their own dominant strategy.

Free-rider: The concept refers to a situation where some individuals in a population either consume more than their fair share of a common resource, or pay less than their fair share of the cost of a common resource. It is a situation where public goods are under-provided (or not provided at all) because individuals are able to consume the good by paying little or nothing towards the cost.

Herd Behaviour: It is the tendency for individuals to mimic the actions (rational or irrational) of a larger group. Individually, however, most people would not necessarily make the same choice. Some reasons for this behaviour are: (i) social pressure of conformity; and (ii) common rationale that it is unlikely that such a large group could be wrong. The latter is especially prevalent in situations in which an individual has very little experience.

Moral Hazard: Moral hazard occurs under a type of information asymmetry, where one party, called an agent, acts on behalf of another party, called the principal. The agent usually has more information about his or her hidden actions or intentions than the principal does, because the principal usually cannot completely monitor the agent. The agent may have an incentive to pursue that hidden action (which is inappropriate from the viewpoint of the principal) if the interests of the agent and the principal are not aligned.

Nash Equilibrium: In the non-cooperative strategic game (static game under complete information), it is the mutually best response strategy. The term is used in game theory to describe an equilibrium where each player's strategy is optimal given the strategies of all other players. It exists when there is no unilateral profitable deviation from any of the players involved. Nash Equilibria are self-enforcing i.e. when players are at a Nash Equilibrium they have no desire to move because they will be worse off.

Negative Externality: A negative externality occurs when an individual or firm making a decision does not have to pay the full cost of the decision thereby inflicting the

	cost on the third party for which he or she is not compensated. If a good has a negative externality, then the cost to society is greater than the cost the consumer is paying for it, thereby resulting in market inefficiencies unless proper action is taken. Pollution is an example of negative externality.
Watershed	Is defined on the basis of water drainage basin. The smaller watershed is based on a single drainage. As one basin joins another one, the size and the concept of the watershed changes.

15.8 SUGGESTED REFERENCES FOR FURTHER READING

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Note: Other references can be accessed by google search.

15.9 ANSWERS/HINTS TO CYP EXERCISES

Check Your Progress 1

1) See 15.2 and answer.

2) See 15.2.1 and answer.

3) See 15.2.2 and answer.

4) See 15.2.3 and answer.

Check Your Progress 2

1) See 15.3.1 and answer.

2) See 15.3.2 and answer.

3) See 15.3.2 and answer.

4) See 15.3.3 and answer.

5) See 15.3.4 and answer.

Check Your Progress 3

1) See 15.4 and answer.

2) See 15.4 and answer.

3) See 15.4.1 and answer.

4) See 15.4.2 and answer.

5) See 15.4.2 and answer.

Check Your Progress 4

1) See 15.5 and answer.

2) See 15.5.1 and answer.

3) See 15.5.1.2 and answer.

4) See 15.4.1.3 and answer.

5) See 15.4.1.3 and answer.

6) See 15.5.1.4 and answer.

7) See 15.5.1.4 and answer.