Indira Gandhi
National Open University
School of Social Sciences

MEC-108
Economics of Social Sector and Environment

Block

1

SOCIETY, ENVIRONMENT AND ECONOMY

Expert Committee

Prof. Joyashree Roy
Jadavpur University
Kolkata

Prof. S. P. Singh
I. I. T. Roorkee
Roorkee

Prof. S. Sandhya
Central University of Hyderabad
Hyderabad

Prof. Duraisamy
Madras Institute of Development Studies
Chennai

Prof. Padmaja Mishra
Utkal University
Bhubaneshwar

Dr. Subrata Mandal
Ambedkar University
Delhi

Prof. Saumen Chattopadhyay
ZHCES, Jawaharlal Nehru University
New Delhi

Prof. Gopinath Pradhan
School of Social Sciences
Indira Gandhi National Open University
New Delhi

Prof. Narayan Prasad
School of Social Sciences
Indira Gandhi National Open University
New Delhi

Prof. Kaustuva Barik
School of Social Sciences
Indira Gandhi National Open University
New Delhi

Sh. Saugato Sen
School of Social Sciences
Indira Gandhi National Open University
New Delhi

Dr. B. S. Prakash **(Convener)**
School of Social Sciences
Indira Gandhi National Open University
New Delhi

Course Coordinator : Prof. B.S. Prakash

Block Preparation Team

Unit No.	Resource Person (Unit Writer)	Format and Language Editing (Units 1 to 3)	Editor (Content) (Units 1 to 3)
1	Dr. S.P. Singh Professor of Economics I.I.T., Roorkee.	Dr. B.S. Prakash Professor of Economics SOSS, IGNOU, New Delhi	Dr. Joyashree Roy Professor of Economics Jadavpur University Kolkata
2	Dr. Indrani Roy Chowdhury Associate Professor CSRD, JNU, New Delhi		
3	Dr. Sukanya Das Assistant Professor Department of Policy Studies TERI University, Delhi		

Material Production

Mr. Manjit Singh
Section Officer (Publication)
School of Social Sciences
IGNOU

M/s ADA Graphics
New Delhi

April, 2016

ISBN-

Further information on Indira Gandhi National Open University courses may be obtained from the University's office at Maidan Garhi, New Delhi-110 068.

Printed and published on behalf of the Indira Gandhi National Open University, New Delhi by Director, School of Social Sciences.

Lasertypesetted at Graphic Printers, 204, Pankaj Tower, Mayur Vihar, Phase-I, Delhi-110091.

Printed at :

COURSE INTRODUCTION

Issues of development, as against merely focusing on growth, have caught the attention of policy planners in the recent years. This concern has basically arisen due to the recognition of the fact that for achieving the objectives of 'inclusive growth', unless the interests of marginalised sections including the depletion of environmental resources used in the production process are duly taken into account, the resulting growth process will accentuate the inequality in the society. The former has led to increased emphasis on improving the access and achievements in the sectors of education and health. The latter has focused on controlling the environmental pollution on the one hand and duly account for the environmental resources used in the System of National Accounts (GDP) of the countries, through Green Accounting, on the other.

The present course of 6 credits, distributed over **six blocks**, is aimed at equipping the students of economics on the related issues of forces influencing the demand for and supply of educational/health/environmental services. The 19 units in the course, focuses on: (i) the methods of measurement of indicators influencing their demand and supply, (ii) identification of determinants, and (iii) 'institutional and policy' mechanisms required to deal with the related issues. Brief outline of block-wise contents are as follows.

Block 1 begins with an outline of the interrelationship between society, state and markets. Dealing in particular on the concepts of poverty and inequality, the block focuses on issues of market failure, common property rights, etc. The interface between poverty, population, affluence and environment are discussed.

Block 2 deals with the issues of demand, supply and determinants of 'education'. Whether education is a public or merit good and how the benefits of education are measured is discussed. The issue of 'funding' the educational services and how in its production the educational services are different from that of other consumption goods is explained. The various determinants of education, how education makes an important economic contribution to development by enhancing the basic human capability are also explained. A perspective of international practices followed in achieving the funding requirements of acquiring education is presented.

Block 3 deals with the issues of health. Measurement of health, the relationship between health input and health output indicators, supply factors which affect the demand for health, distinction between private demand and the social demand for health services, etc. are covered. The concept of health production function, its efficiency conditions, cost functions in healthcare and its estimation, issues of pricing health services, etc. are also discussed. Determinants of demand for health and its supply are covered in the last unit of the block.

Block 4 addresses the economics of environmental and natural resources. Using the approach of dynamic optimization, the economics of demand for non-renewable resources are dealt with in Unit 10. The block then moves on to cover the issues of supply of environmental and ecosystem services. Under this, the concept of non-market valuation, valuation tools, the production function approach and the alternative related goods approach, etc. are explained. The determinants of environmental resources concerning the renewable resources are discussed in the last unit of this block.

Block 5 deals with the issues of Sustainable Development. Different indicators and indices, the flaws in the conventional 'system of national accounts' (SNA) and the modifications required to make the SNA environmentally accountable (i.e. green

accounting), the concept of environmental cost-benefit analysis, etc. are explained. Concepts of common property and its management, global environmental externalities and climate change, etc. are discussed in the last unit (Unit 15) of this block.

Block 6 deals with the role of institutions and policies (for each of the three sectors viz. education, health and environment) covering a mix of both theoretical and practical relevance. In this, issues of market failure and role of policy, IPR, regulation of private health insurance market, economic instruments to manage environmental resources (e.g. Pigouvian Tax, Coasian solution), pollution abatement options, energy security and pricing, etc. are discussed.

BLOCK INTRODUCTION

This introductory block to the course has three units. **Unit 1** is on: Society, State and Market. Bringing out the interrelationship between 'society, state and markets', the unit underscores the importance of the role of State in a market economy. The two important economic dimensions of a developing economy, namely poverty and inequality, are dealt with in detail. The relationship between 'inequality and economic growth' (by means of the inverted-U hypothesis) is explained. With these theoretical concepts introduced, suitably interspersed for empirical exercises to illustrate the computational aspects, the unit concludes with an account of post-reform poverty trends in India.

Unit 2 is on 'Economy and Environment'. The interaction between economy and environment, in terms of the balance in circular flow of material, the laws of thermo-dynamics and the life support system and sustainability are first explained. The characteristics of market failure in the context of environmental goods are then covered. The importance of property rights and common properties (in terms of Coase theorem and its limitations) is explained. The concept of future time preference and discount rate, along with the concept of Cost Benefit Analysis (CBA), is finally dealt with.

Unit 3 is on 'Society and Environment'. The linkage between poverty & environment, population & environment and affluence & environment are discussed in detail. The impact of environmental degradation on the poor, and on poverty and resource management, is explained. The factors explaining population-environment linkages and the policy implications of population-poverty-environment interface are discussed. The concepts of IPAT and KAYA identities, along with the major considerations for reformulating the IPAT, are explained towards the end of the unit.

Blank Page

UNIT 1 SOCIETY, STATE AND MARKET

Structure

1.0 OBJECTIVES

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

- highlight the interrelationship between society, state and markets;
- outline the role of state in a market economy;
- explain the major methods of poverty measurement;
- discuss the concept of inequality and its major methods of measurement;
- state the axioms of poverty and inequality measures;
- describe the relationship between inequality and economic growth in terms of the 'Inverted-U Hypothesis'; and
- analyse the post-reform poverty trends in India.

1.1 INTRODUCTION

With the growing complexity of development and emergence of modern age society, the organisation of society gradually began to be segmented into three realms viz. the state system (represented by the government institutions and organizations); the market system (represented by business entities and organizations); and civil society (represented by non-government and community-based organizations). The interface among these constituents forms the structural foundation of modern society. In this unit, beginning with an outline of the concepts of society, state and market we examine the interaction among them. The role of the state in the market economy, in the light of issues of social concern like poverty and inequality, will also be discussed. We finally take a look at the post-reform trends in poverty in India.

1.2 INTER-RELATIONSHIP BETWEEN SOCIETY, STATE AND MARKETS

The term society implies a group of individuals sharing a defined territory and culture including the relationships among the people and the institutions within that group. It is used in different ways. For instance, while it is used to refer to an association of people such as consumer's society, cooperative society, etc., it is also used in a more general sense of a rural or urban society. In sociological terms, the term 'society' refers to a network of social relationship and interactions. Thus, a system of social relationships is the most important aspect of society. 'State', on the other hand, is a sovereign entity holding supreme rule over its territory. It is a body of government making all rules and regulations and consists of officials, institutions and corporations. More specifically, the term 'government' comprises of all constituents of the Union, State and Local governments along with all the government institutions and corporations under their control.

The term 'market' in economics does not necessarily mean a physical place where goods and services are bought or sold. It refers to any medium which allows customers and sellers to interact with each other and facilitate a transaction. Such exchanges between sellers and buyers can take place online where the agents do not meet physically. The equilibrium price of a product or service in a market is determined by the interaction of supply and demand i.e. when the market is in equilibrium, the prices will not change unless some external factors change the very conditions of supply and demand. In a perfectly competitive market, the price mechanism ensures the efficient allocation of resources. However, since in reality markets are rarely perfect it is natural for some distortions in the market to always prevail. It is in the context of dealing with such situations that the role of the state becomes critical to make the markets work efficiently.

Although with the advancement of society, the state and the market can be separated from the society as an institution, they are nevertheless highly interrelated with each other. In a democratic society, members of the society play a dominant role in influencing the decision making process of the state. In this, various social groups like civil society organisations, community based organisations and non-governmental organisations play an important role. The state also facilitates their involvement by providing various rights to their citizens in the form of constitutional rights, right to vote, etc. thereby making them participate in the decision making processes.

The above relationship between the state, society and market is, thus, dependent on the system of democratic governance which allows for the formation of the societal groups. Such groups and organisations complement the government and the market by

their vigilance in keeping the governance system well functioning thereby aiding the attaining of efficiency and justice in economic growth. The market makes efficient allocation of resources only when there are no externalities. A vibrant and vigilant civil society helps by making the state and market more responsive, accountable and efficient. For this, a strong and able governance structure is required. In such conditions, many market distortion can be expected to be corrected through effective state intervention. However, since many a times government failures also can occur, the market failures can be minimised by a more developed and responsive civil society/organisational groups. An illustration of a situation when state intervention in the market to promote public interest can be cited is the price controlling mechanism using the instruments of taxes and subsides. For instance, if the government wants to increase the market demand for low carbon energy such as solar energy, it can be done through providing tax incentives and subsidies to invest in producing solar energy. In other words, although markets can allocate resources efficiently, the state has to provide an efficient incentive and regulatory framework to facilitate the market to work efficiently. Since market is not always competitive, involvement of the government and social institutions are equally crucial in the efficient functioning of the market and the economy. Thus, development and activation of social capital and its use in the state and market governance is quite essential for economic, political and social development of a country. We shall read more about the theoretical arguments for government intervention in the succeeding section.

1.3 ROLE OF STATE IN MARKET ECONOMY

In a market economy, price mechanism makes an efficient allocation of resources to produce various goods and services through the forces of supply and demand. However, market failures and market imperfections, which occur largely due to externalities and lack of information to consumers and producers, adversely affect the functioning of market in efficient allocation of the scarce resources. For instance, in the absence of state regulation, producers may generate negative externalities by releasing solid, liquid and gaseous wastes into the atmosphere, as the cost of dumping such wastes may be negligible to them. Further, producers can also exploit the consumers through forming of cartels and exercising monopoly power. In such situations, the role of the state is critical in making the markets work in a fair and efficient manner by taking measures to internalise the externalities.

Role of the state in the market economy has been debated for long. Classical economists advocated minimum role for government by arguing that the 'best government is the one which governs the least'. However, the great depression of 1930s made the economists rethink the relevance of government intervention in the market economy. Experiences of a number of developing countries in the recent decades also indicate that not only the market fails in resource allocation, but sometimes even the government fails in its functions to remove the market distortions. In fact, government failures may be more detrimental to the economic development than the market failures. Nonetheless, economists advocating free markets suggest that the state should limit its functions to provide an effective legal system and a stable macroeconomic environment. For the latter, the government should involve itself in providing the merit goods and build socio-economic infrastructure leaving the rest for the operation of market forces. Their argument is that market failures are no longer enough to justify the state's role as there is no guarantee that the state will be able to remove those distortions. In this context, Prof. Paul Streeten observes that just as government action can lead to rent seeking (i.e. grab unearned money), private market players can also collude and seek rent. He, therefore, suggests that the state should be a vigilant watchdog to prevent the rent seeking behaviour in general which itself facilitates the market to function efficiently.

The need for state interventions in the market economy derives from two theories: the *public interest theory* and the *interest group theory*. According to the public interest theory, state's role in the market is to safeguard public interest by addressing the factors of imperfect competition, incomplete information and externalities. These three factors, commonly associated with market economy, necessitate state regulations and controls. The first and foremost role of the state is, therefore, to prevent concentration of market power by promoting competitiveness among economic entities. State intervention is also required because society has not only incomplete access to information but acquiring information may involve more costs than benefits. The state can, therefore, establish well-designed liability rules to protect the consumers in case the quality of products fails to meet the specified standards. For instance, in the absence of government regulations, individual units (e.g. sugar factory) may not treat their solid, liquid and gaseous wastes before releasing them into the environment. In order to internalise the negative externalities from such actions, the government can establish a set of regulations so that the polluters bear the cost of such bad environmental products generated while producing the goods and services. According to the interest group theory, state intervention in the market is required to protect the interest of specific groups or regions. For instance, in order to attract more private investment in energy generation by adopting green and clean sources, the government can provide input subsidies and tax exemptions to promote the investment in alternative sources of energy like solar, wind or bio-energy.

The role of state is, therefore, to remove instances of market failures by creating an enabling environment under which the market can work efficiently. For this purpose, in addition to instituting a set of legally binding rules and regulations, the state has to establish efficient institutions to implement them properly. The recent global economic and financial crisis brings the role of the state back into focus, as unregulated market forces may land the economy in a crisis. In brief, therefore, we can summarize the role of the state in the market economy as follows.

1. The most critical role of the state is to provide economy with a legal structure without which market cannot perform properly. The legal structure comprises of various rules and regulations, including property rights, enforcement of contracts, legislations, etc. Market system works only when the state ensures property rights.

2. Competitive market is required as it provides correct price signals to both the producers and consumers. A competitive market environment must therefore be established by controlling the monopoly power of business entities.

3. The state should strive to protect the welfare of poor and marginalized groups by implementing affirmative policy actions. This is important to reduce inequality in the society.

4. Government's role is also important in making provision for public and quasi-public goods as market generally fails to efficiently deliver these goods. Examples of such public goods are defence, security, police protection and the judicial system whereas education and healthcare services are examples of quasi-public (merit) goods that the market generally under-provides. Provision of these public/quasi-public goods are necessary for promoting the investment required for private goods. However, since government has limited resources, quasi-public/merit goods can also be produced under public-private partnership arrangements.

5. The fifth role of the state is to provide a stable macroeconomic environment for promoting growth with stability in the economy. Fiscal and monetary policies are

instruments used to control inflation/depression in the economy to accelerate the growth process.

6. The most critical role of the state, especially in the developing countries, is to reduce poverty and inequality across regions, gender, social groups and sectors thereby facilitating the promotion of a more inclusive and equitable development process. ***This is because economic growth is necessary but not sufficient for equitable development.*** The state, therefore, needs to step-in to create equal opportunities for all sections of society by enhancing the capability of poor and marginalized groups to enable them to actively participate in the market economy.

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

1) In what way is the government or state important in a free market economy?

.....

.....

.....

.....

2) How is a vigilant civil society helpful in making the state and markets function well?

.....

.....

.....

.....

3) In a free market economy, specifically what role was envisaged for the government by the classical economists?

.....

.....

.....

.....

4) What are the three factors that generally afflict a market economy in its efficient functioning? How can state intervention help in these?

.....

.....

.....

.....

5) Do you think economic growth alone is enough for ensuring equitable development? Justify your viewpoint with illustrations.

.....

.....

.....

.....

1.4 POVERTY

There are two concepts of poverty— absolute and relative. Absolute poverty refers to the minimum basic needs of human beings, such as, food and nutrition, clothing, shelter and preventive and protective healthcare, necessary for their survival and physical health. In view of this, in developing countries like India, absolute poverty attracts more attention of policy makers than the relative poverty. This approach involves defining a minimum standard of living below which an individual or household is considered to be poor. Based on the income required for maintaining this minimum level of living, a poverty line is estimated. A distinction is then made between the poor and non-poor depending on persons who lie either below or above this defined line of poverty. That is, a household having income level below the subsistence level is termed as poor and above it as non-poor. In India, poverty line is drawn on the basis of per-capita (adult) daily intake of 2,400 calories of food for the rural and 2,100 calories for the urban areas. If the monthly per-capita consumption expenditure (MPCE) of a household is not sufficient to buy this much of calories, then the household is designated as below poverty line (BPL).

For estimating poverty, consumption expenditure is considered more appropriate than income as consumption not only depends on the current income but also on the past savings, accumulated assets and debts. However, this minimum calorie requirement is not static and may change with the change in the nature of work. For instance, recently Planning Commission of India (Tendulkar Expert Group, 2009) estimated the poverty line on less number of calories (than specified above) as people require less calories due to decline in the physical work performed now than before. A later group (Rangarajan Expert Group, 2012) also considered expenditure on education, health, shelter, conveyance, etc. to measure poverty. In view of this, poverty ratios estimated by this group was much higher than that estimated by the preceding group. Thus, absolute poverty indicates the extent of deprivation in terms of access to food, health, housing, education and other basic amenities.

Absolute poverty is not related to the income/consumption distribution whereas relative poverty depends on it. Therefore, measurement of absolute poverty is relevant for short and medium term periods while for long term perspective, it is the relative poverty which is more relevant. A relative poverty line is an explicit function of the income distribution – namely, a constant fraction of some income standard. It interprets poverty in relation to the prevailing standards of the society at the time. Thus, the cut-off below which a household is considered to be relatively poor varies proportionally with the standard of income considered. Therefore, relative poverty line is defined in terms of a certain percentage (say 40 percent) of a country's median or mean level of income. For instance, a household may be called relatively poor if its income is below 40 percent of the national average. Selection of cut-off percentage may vary across time as a certain level of income that is above the poverty line in one income distribution may actually lie below the poverty line considered in another distribution. Thus, the concept of relative poverty is more relevant in developed economies, where the number of absolute poor may be negligible.

1.4.1 Measurement of Poverty

There are various methods of measuring poverty. Three major methods of measuring poverty viz. (i) the headcount ratio, (ii) the poverty gap ratio and (iii) the squared poverty gap ratio are discussed here.

1.4.1.1 Headcount Ratio

The headcount ratio of measuring poverty is defined as the percentage of the total population that is poor. Thus, it is measured as the proportion of the population that is counted as poor. It is estimated as:

$$P_0 = \frac{N_P}{N}$$

Where P_0 is headcount ratio; N_p is the number of poor; and N is the total population. If the monthly per-capita consumption expenditure (MPCE) of 60 million households out of 179 million households of rural India is below the cut-off point, the headcount poverty ratio is = 60/179 = 0.3352. This means 33.52 percent of rural households in India are below the poverty line. If the value of MPCE (say Y_i) in a sample of household is below the poverty line (say Z), i.e. $Y_i < Z$ then the i^{th} household is counted as poor. If the value of $Y_i > Z$, then the i^{th} household is counted as non-poor. Thus, the aggregate value of 'proportion of poor household' by the headcount method (P_0) in a region can be represented as:

$$P_0 = \frac{1}{N}\sum_{i=1}^{N} \text{Yi} \quad (if\ Y_i < Z)$$

The above can be illustrated by an empirical example. Suppose the MPCE of 8 households in two regions is as per the values presented in Table 1.1 and the value of Z i.e. the threshold level of income to regard a family as poor is kept as Rs. 800. Since there are three households in each of the two regions with the MPCE below Rs. 800, the headcount ratio of poverty for the sample households of both the regions I & II, comes out uniformly as 0.375.

Table 1.1: Poverty Estimates by Headcount Ratio Method

Region	MPCE (in Rs.) in 8 Sample Households								Headcount Ratio (P_0) Z = Rs. 800
	1	2	3	4	5	6	7	8	
Region I	950	1100	1000	975	750	775	790	1400	3/8 = 0.375
Region II	1250	1150	1400	1100	550	600	490	1200	3/8 = 0.375

Thus, although the headcount ratio is simple to estimate, and therefore widely used to estimate absolute poverty, it has several weaknesses. First, it does not tell us anything about the relative intensity of poverty in the two regions. Second, it does not indicate how poor the poor really are as a slight transfer of income from among the poor families alters the poverty estimate drastically. For instance, if Rs.25 is transferred from household No.7 to household No.6 and Rs.10 from household No. 5 to household No.7, the headcount ratio of poverty in Region I gets reduced from 0.375 to 0.125. Third, the headcount ratio, calculated from household level consumption data, does not capture the discrimination in consumption level across members like, say, by gender. From these weaknesses point of view, the measure of poverty calculated as 'poverty gap ratio' is superior to the headcount ratio.

1.4.1.2 Poverty Gap Ratio

For studying the intensity of poverty, estimation of poverty gap ratio is useful. Expressed as a percentage of poverty line, it tells us the extent to which individuals, on average, fall below a poverty line. It is a key indicator that measures how far the extremely poor fall

below the poverty line reflecting both the depth and incidence of poverty. It is estimated as:

$$P_1 = \frac{1}{N}\sum_{i=1}^{N}\frac{G_i}{z}$$

Where P_1 is poverty gap index; N= number of households; G_i = poverty gap i.e. the difference between the MPCE Y_i and the level of Z taken as the minimum income required for basic sustenance. If the value of $Y_i > Z$, then G_i is taken as equal to 0 and if $Y_i < Z$, then G_i is taken as equal to $Z - Y_i$. Computation of poverty gap index is shown in Table 1.2. The poverty gap index for Region I (0.0133) is less than that of Region II (0.119) while by the headcount ratio the estimated poverty level was the same for both the regions. Thus, by knowing the poverty gap index, the policy planners can better target the schemes to minimise or eliminate poverty. However, poverty gap index also has limitations. Like the headcount ratio, it also violates Dalton's transfer principle (see subsequent section 1.5.2) as shown in Table 1.3. In both the regions, P_0 and P_1 are the same whereas apparently the severity of poverty in Region II is more than Region I. Thus, Poverty gap index can give us an idea of intensity of poverty between the regions but cannot provide a measure of the severity of poverty.

Table 1.2: Poverty Estimates by the Poverty-Gap Ratio Method

Region	MPCE (in Rs.) in 8 Sample Households								Poverty Gap Index (P_1)
	1	2	3	4	5	6	7	8	
Region I	950	1100	1000	975	750	775	790	1400	Z = 800
$G_i = Z - Y_i$	0	0	0	0	50	25	10	0	
G_i/Z	0	0	0	0	0.0625	0.03125	0.0125	0	0.10625/8 = **0.0133**
Region II	1250	1150	1400	1100	550	600	490	1200	
$G_i = Z - Y_i$	0	0	0	0	250	200	310	0	
G_i/Z	0	0	0	0	0.3125	0.25	0.3875	0	0.95/8 = **0.119**

Table 1.3: Headcount Ratio and Poverty Gap Ratio in Two Regions

Region	MPCE (in Rs.) in 7 Sample Households							Z = Rs. 800	
	1	2	3	4	5	6	7	P_0	P_1
Region I	1200	1100	1000	975	900	700	700	0.286	
$G_i = Z - Y_i$	0	0	0	0	0	100	100		
G_i/Z	0	0	0	0	0	0.125	0.125		0.250 ÷ 7 = 0.036
Region II	1200	1150	1400	1100	850	750	650	0.286	
$G_i = Z - Y_i$	0	0	0	0	0	50	150		
G_i/Z	0	0	0	0	0	0.0625	0.1875		0.25 ÷ 7 = 0.036

Note: P_0 is Headcount Ratio (i.e. no. of households below Z ÷ 7) and P_1 is Poverty Gap Ratio ($1/7 \sum G_i/Z$)

1.4.1.3 Squared Poverty Gap Ratio

The squared poverty gap ratio, which is similar to the poverty gap ratio discussed above (but for considering the sum of squares of G_i/Z values), is helpful to know the severity of poverty. As a weighted sum of poverty gaps, where the weights are the proportionate poverty gaps themselves (i.e. a poverty gap of 'x' percent is given equal weight of 'x' percent), it is sensitive to the prevalence of the poor by the extent to which their incomes fall below the poverty line. This is in contrast with the poverty gap ratio method, where the gaps are all weighted equally. Hence, by squaring the poverty gap index, the measure implicitly puts more weight on observations that fall below the poverty line. The Squared Poverty Gap Ratio (P_2) is obtained as:

$$P_2 = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{G_i}{z}\right)^2.$$

To see the differential impact of P_2 as compared to those of P_0 and P_1 discussed above, let us once again take the same example that was used to calculate P_0 and P_1 (Table 1.4). Since the value of P_2 in Region 2 (0.04) is higher than that for Region 1 (0), as a measure of severity of poverty, P_2 is more sensitive and powerful than the headcount ratio and the equi-weighted poverty gap ratio.

Table 1.4: Measure of Poverty by the Squared Poverty Gap Ratio

Region	MPCE (in Rs.) in 8 Sample Households								Squared Poverty Gap Ratio (P_2)
	1	2	3	4	5	6	7	8	
Region I	950	1100	1000	975	750	775	790	1400	Z = 800
$G_i = Z - Y_i$	0	0	0	0	50	25	10	0	
G_i/Z	0	0	0	0	0.0625	0.03125	0.0125	0	
$(G_i/Z)^2$	0	0	0	0	0.0039	0.0010	0.0002	0	$1/8\sum(G_i/Z)^2 = 1/8* 0.0051 = 0.00064 \approx 0$
Region II	1250	1150	1400	1100	550	600	490	1200	
$G_i = Z - Y_i$	0	0	0	0	250	200	310	0	
G_i/Z	0	0	0	0	0.3125	0.25	0.3875	0	
$(G_i/Z)^2$	0	0	0	0	0.0977	0.0625	0.1502		$1/8\sum(G_i/Z)^2 = 1/8* 0.3104 = 0.0388 \approx 0.04$

1.4.2 Multidimensional Concept of Poverty

The discussion in the preceding sub-sections is of uni-dimensional concept of poverty and its methods of measurement. However, poverty is multi-dimensional in nature and hence cannot be realistically captured only by the calorie-based or the per-capita consumption based approach. In measuring multidimensional poverty, various dimensions and indicators like education, health, employment status and household living conditions are used. Further, some of these dimensions may have more than one indicator. For instance, education dimension can consist of school enrolment and years of schooling. Likewise, household living conditions may comprise of access to safe drinking water, sanitation and clean cooking fuel, etc.

The Oxford Poverty and Human Development Initiative (OPHI) estimates the multi-dimensional poverty index (MPI) for different countries, using equally weighted three dimensions viz. education, health and living standards. However, for capturing these three dimensions it uses a total of 10 indicators. Specifically, for the 'education dimension' it uses two indicators: (i) years of schooling (considered deprived if no household member has completed five years of schooling); and (ii) school attendance (considered deprived if any school-aged child is not attending school in years 1 to 8). For the 'health dimension' also it considers two indicators: (i) child mortality (considered deprived if any child in the family has died); and (ii) nutrition (considered deprived if any adult or child is malnourished). For the 'living standards' dimension it considers six indicators viz. (i) electricity (deprived if the household has no electricity); (ii) drinking water (deprived if the household lacks access to clean drinking water or clean water is more than a 30-minute walk from home); (iii) sanitation (deprived if the household does not have adequate sanitation or has shared toilet; (iv) flooring (deprived if the household has a dirt, sand or dung floor); (v) cooking fuel (deprived if the household cooks with wood, charcoal or dung); and (vi) assets (deprived if the household does not own more than one of items radio, TV, telephone, bike, motorbike, or refrigerator) and does not own a car or tractor. A person is identified as multi-dimensional poor if he/she is deprived in one-third or more of these ten weighted indicators.

The headcount ratio can also be used to measure multi-dimensional poverty if we take the proportion of poor (q) in population (n) as those who are multidimensional poor. The multi-dimensional poverty 'H' is computed as:

$$H = \frac{q}{n}$$

where 'q' is number of multidimensional poor and 'n' the total population. The intensity of poverty (A) or the breadth of deprivation, which captures the average weighted count of deprivations experienced by the multidimensional poor. The intensity of poverty (A) is computed as:

$$A = \frac{\sum_1^q c}{q}$$

where 'c' is the total weighted deprivations experienced by the poor. The multidimensional poverty index (MPI) is the product of headcount ratio (H) and the intensity of poverty (A). The MPI is computed as:

$$MPI = H \times A$$

Alkire and Seth (2013) estimate the MPI for India using national family health survey (NFHS) data for 1998-99 and 2005-06 (Table 1.5). Their estimates show that the MPI declined from 0.300 to 0.251 (i.e. a net decline of 16 percent). The decrease was mainly due to a reduction in the percentage of people identified as poor (H) and reduction in the intensity of poverty (A).

Table 1.5: Multi-dimensional Poverty in India – 1999 and 2006)

	Rural			Urban			Total		
H/A/MPI	1999	2006	%Change	1999	2006	Change	1999	2006	% Change
H (%)	68.6	60.8	7.8	24.4	20.5	3.9	56.8	48.5	-8.3
A (%)	53.6	52.4	1.2	47.4	46.5	0.90	52.9	51.7	-1.2
MPI	0.368	0.319	0.049	0.116	0.096	0.02	0.300	0.251	-0.05

Source: Alkire and Seth (2013).

Note: MPI for the years 1999 and 2006 is arrived at by multiplying H with A in value without percents (e.g. 0.686 x 0.536 = 0.368). MPI can also be indicated as percentages by multiplying their value by 100 (e.g. 36.8% for rural in 1999). The computational requirements of H and A is outlined in the source cited.

1.4.3 Axioms of Poverty Measures

Nobel laureate Amartya Sen suggested a number of desirable properties (or axioms) that any measure of poverty should possess. The six axioms proposed by him as required for any poverty measure to possess are the following.

1. ***Focus****:* The measure of poverty should not be affected by changes in the incomes of non-poor. In other words, the poverty measure should entirely focus on the incomes of the poor as the poverty ratio is not affected by the income of the households above the poverty line.

2. ***Symmetry****:* The poverty measure should not be affected if two households switch incomes i.e. the poverty index should be scale invariant. This means that if the population doubles in size, while everything else is maintained in the same proportions, it should remain unchanged.

3. ***Population Independence****:* If two or more identical populations are pooled, the poverty index should be unchanged. In other words, the index should be invariable with the replication and pooling of identical populations.

4. ***Monotonicity****:* The axiom requires that if the income of a poor individual who is below the poverty line increases, the poverty index should decrease. The monotonicity is said to be strong (i.e. 'strong monotonicity' or SM) if the poverty index decreases whenever the income of a poor individual rises. The weak monotonicity (WM) axiom requires that the poverty index should decrease whenever the income of the poor individual rises but the individual continues to remain poor. The distinguishing feature between the SM and WM is that 'while WM requires the poverty index to decrease only if the poor individual is not lifted out of poverty after the increase in income, the SM requires the index to decrease even in the case when the poor household is lifted out of poverty with the increase in income'. Thus, SM implies WM.

5. ***Transfer****:* A regressive transfer between two poor households should increase the poverty index, while a progressive transfer between the two should reduce the poverty index, provided both the households continue to be poor after the transfer i.e. a poverty measure should be sensitive to the degree of inequality between the incomes of the poor households. It should rise when inequality among them increases (through a regressive transfer) and it should fall when it decreases (through a progressive transfer).

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

1) What criteria is used for classifying a family as poor or non-poor in India?

.....

.....

.....

.....

2) How is absolute poverty defined? What components of expenditure are included in its measurement?

.....

.....

.....

.....

3) In what way is 'relative poverty' different from 'absolute poverty'?

.....

.....

.....

.....

4) How is the 'headcount measure' of poverty defined? What are its strengths and weaknesses?

.....

.....

.....

.....

5) How is the measure of poverty provided by the 'poverty gap ratio' superior to that of 'headcount ratio' method? How is it estimated?

.....

.....

.....

.....

6) In what way 'squared poverty gap ratio' method of measuring poverty superior to the 'poverty gap ratio' method? How is it computed?

.....

.....

.....

.....

7) Can the 'headcount ratio' of measuring poverty be useful for computing a 'multi-dimensional poverty index'? Indicate with relevant expressions how a MPI brings out the 'intensity of poverty' or deprivations.

.....

.....

.....

.....

8) Distinguish between the strong and the weak monotonicity requirement of an ideal poverty measure.

.....

.....

.....

.....

1.5 INEQUALITY

Income inequality obstructs the process of poverty reduction thereby weakening the very pace of economic growth. It affects the human capital formation as those at the bottom of income pyramid face severe economic constraints in investing in education and health which in turn limits their income earning potential. In addition, it can also create political instability and weaken the institutional framework of a country.

From a public policy point of view, therefore, it is necessary to differentiate between inequality of opportunities and inequality of outcomes. Inequality of opportunities exist in any society due to differences in individual circumstances that are beyond the control of individual, such as gender, caste, location of birth, parental education, etc. Such inequalities reflect the institutional weaknesses and social exclusion and are to be targeted through affirmative policy actions. Inequality of outcome basically exists due to differences in the individual efforts in availing the opportunities. While some inequality in outcome is part of the normal functioning of a market economy, a substantial component of inequality reflects the inequality of opportunities itself. For instance, children of illiterate parents may not educate their children due to family/economic circumstances.

The role of the state is quite significant in reducing the inequalities across sectors, location, gender and social groups by designing a set of policy responses which reduce the inequality of opportunities. Such policy responses must aim at building the human capital to make the growth process more inclusive and employment-oriented. In particular, the human capital base of marginalised group can be enhanced by investing more in improving their level of education and health, providing effective social safety-net and creating productive income and employment opportunities.

1.5.1 Methods of Inequality Measurement

Like poverty, inequality is also multi-dimensional in nature as various dimensions of inequality are interrelated. For instance, inequality in income and wealth among group of people also creates inequality in other dimensions of living standards like food and nutrition, shelter, access to basic amenities, education, health, material well-being, etc. Income inequality measures the relative position of different households within an income distribution. Unlike the absolute poverty measure, inequality measure is not affected by the absolute number of households since it measures the relative position of a household in the distribution. Level of inequality can be reduced by transferring income from high income groups to low income groups. Some important inequality measures are the following.

1.5.1.1 Lorenz Curve

The Lorenz Curve first ranks the population according to different levels of consumption/ income and then plots the cumulative proportion of consumption/income against the cumulative proportion of the population enjoying that level of consumption/income (Figure 1.1). The area between the Lorenz curve and the 45 degree diagonal line (which is called the line of equality) i.e. AEDF, divided by the total area under the 45 degree line (i.e. AEDB) gives a measure of inequality (called as the Gini coefficient discussed in next section). While the concepts of Lorenz curves and Gini coefficients are most commonly applied to measures of consumption, income and asset ownership, they can equally be applied to other variables that are continuous in nature. If we refer the curve AEDF plotted as L(p), where the lowest 'p' percent of households earn the lowest 'p' percent of income, it follows that greater the share of 'p', the more equal is the distribution of income in the economy. Alternatively, since the share of the total income of the

richest 'p' proportion of the population is then given by '1 – L(p)', the greater is this share, the more unequal is the distribution of income in the economy. The Lorenz curve typically falls below the line of equality with the total amount of inequality given by the area AEDF. The larger is this area, greater is the inequality.

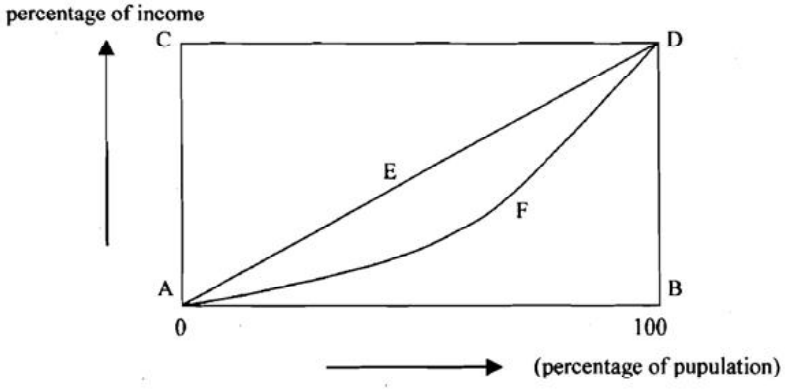

Figure 1.1: The Lorenz Curve

For an illustration of plotting the Lorenz Curve, we can consider a hypothetical sample of 10 individuals having their income as shown in Table 1.6. First, we sort the observations (individuals) in ascending order of income (column 3: the lowest income being 4000 of the individual in Sl. No. 7 being listed first & so on) and rewrite the income of individuals to appear in the ascending order (in column 4). Summing over all incomes, we obtain the sample *aggregate* income of Rs. 73550. We assume each individual to have a population share of 1/10 i.e. 10 percent (P) and cumulate the proportions successively as in column 5 (i.e. the total sample is distributed into 10 quintiles). We then cumulate the income in column 4 to get the figures in column 6 and obtain their percentage share in the total income (73550) as in column 7. By plotting the percentage share in total income in column 7 on Y-axis and the cumulative percentage distribution of population (figures in column 5) on X-axis, we get the Lorenz Curve. It is thus a function of cumulative proportion of ordered individuals mapped onto the corresponding cumulative proportion of their income.

Table 1.6: Illustrated Calculations for Plotting Lorenz Curve for an Income Distribution of 10 Households

Individual/ Household	Income (Rs.)	Individuals Sorted by Ascending order of Income	Income of Households in the Re-Ordered Households	Cumulative % of Population (P)	Cumulative Income	% Share in Total Income L(P)
1	5000	7	4000	10	4000	5.44
2	6500	5	4500	20	8500	11.56
3	9050	1	5000	30	13500	18.35
4	11500	2	6500	40	20000	27.19
5	4500	9	6500	50	26500	36.03
6	8500	8	7500	60	34000	46.23
7	4000	6	8500	70	42500	57.78
8	7500	3	9050	80	51550	70.09
9	6500	10	10500	90	62050	84.36
10	10500	4	11500	100	73550	100.00
Total Income	**73550**		**73550**			

1.5.1.2 Gini Coefficient

Developed by Italian statistician Corrado Gini (1912), Gini coefficient is the widely used method to measure income and consumption inequalities. It is used to measure the degree of concentration in the inequality of a variable in a distribution of its elements. With its values ranging between 0 and 1, it assumes a value of zero when there is perfect equality in society. On the other hand, it takes the theoretical maximum of 1 when in a population the income level of every individual except one is zero. The Gini-coefficient thus gives a summary figure for Lorenz curve. It is given by the ratio of area below the line of equality in the Lorenz curve to the total area of the triangle ABD in Figure 1.1. As said above, the Gini Coefficient (G) is calculated as: ***G = area*** *AEDF/* ***area*** *AEDB*. Since the Gini coefficient lies between zero and one, the inequality increases as the index moves from zero to one. In empirical exercises, the Gini-coefficient is calculated by the formula:

$$G = \frac{1}{n}\left[n + 1 - 2\left(\frac{\sum_{i=1}^{n}(n+1-i)Y_i}{\sum_{i=1}^{n} Y_i}\right)\right]$$

Table 1.7: Computation of Gini Coefficient

Reordered Household	Income (Y_i)	Row Number (i)	n+1-i	(n+1-i)Y_i
7	4000	1	10	40000
5	4500	2	9	40500
1	5000	3	8	40000
2	6500	4	7	45500
9	6500	5	6	39000
8	7500	6	5	37500
6	8500	7	4	34000
3	9050	8	3	27150
10	10500	9	2	21000
4	11500	10	1	11500
Sum	**73550**			**336150**

or,

$$G = \left[\frac{(n+1)}{n} - \frac{2}{n}\left(\frac{\sum_{i=1}^{n}(n+1-i)Y_i}{\sum_{i=1}^{n} Y_i}\right)\right]$$

where n is the number of individuals and Y_i is the income of the individual occupying the i^{th} row of the sorted income data in Table 1.6 . The income of the poorest individual is Y_1 and that of the richest is Y_{10}. The calculation of the Gini is illustrated in Table 1.7 above. The Gini coefficient G is:

$$G = \left[\frac{(10+1)}{10} - \frac{2}{10}\left(\frac{336150}{73550}\right)\right] = 0.186$$

While comparing the same for two or more regions, a lower Gini indicates a higher level of social or economic inequality.

Many other inequality indices have been developed, and some of these have additional desirable properties not satisfied by the Gini coefficient. One such important index is

the Theil index (on which you will study more in the course MEC 009/109 on Research Methods in Economics). Different inequality indices implicitly represent different value judgments, notably on the relative weight to be given to different parts of the distribution. For instance, the simplest way to measure inequality is by dividing the population into five quintiles – from poorest to richest and calculating the proportions of income (or expenditure) that accrue to each level.

1.5.2 Axioms of Inequality Measures

There are five key axioms of inequality measures viz. (i) the principle of transfers; (ii) the principle of population; (iii) the principle of scale invariance; (iv) the principle of translation invariance; and (v) decomposability.

1. The principle of transfers, also known as the Pigou-Dalton principle of transfers, requires that the inequality index should fall with a progressive transfer (i.e. an income transfer from richer to poorer households) and should increase with a regressive transfer (i.e. an income transfer from poorer to richer households).
2. The principle of population requires the inequality index to be invariant to replications of the original population i.e. if the population were to change, the measure of inequality should not change.
3. The principle of 'scale invariance' requires that if income of all households is scaled up or down by the same factor, then the inequality measure should remain unchanged. This ensures that the inequality is a purely relative concept and is independent of the distribution size.
4. The principle of 'translation invariance' requires the inequality index to be invariant to uniform additions or subtractions to original incomes (i.e. invariant to change of 'origin' in the values of income). For example, if Rs.100 is added (or subtracted) uniformly in the income of all households in the distribution, inequality index should remain unchanged.
5. The axiom of decomposability ensures that inequality may be decomposed by population groups or income sources or in any other dimension. This axiom requires a consistent relation between overall inequality and its parts.

1.6 INEQUALITY AND ECONOMIC GROWTH (THE INVERTED-U HYPOTHESIS)

Developed by Simon Kuznets in 1955, the inverted U-hypothesis states that the economic inequality increases with the increase in economic growth in the initial phase of development but after the economy reaches a particular level of development, the inequality starts falling with the increase in level of economic growth. According to this hypothesis, the income inequality follows an inverted-U shape along the stages of economic development i.e. it first rises with the growth of industrialization but declines later due to more and more workers joining high productivity sectors of the economy. Changing sectoral composition of employment and income, and changes in the level of human capital and technical progress at different stages of development, are considered the main reasons for this inverse-U relationship between inequality and economic growth in the economy. The hypothesis explains that initially, the inequality increases with the increase in per capita income, which may happen due to the movement of workers from the low productive sector (say agriculture) to high productive sector (say industry) and increase in physical capital. That is, initially, the investment in physical capital acts as the driver of growth and, therefore, those who save and invest realise more income. Thus, industrialization benefits limited number of people, especially those who possess

financial endowments and entrepreneurial skills. Technical progress is also likely to have a more uneven character at low levels of income as it is initially biased against unskilled labour tending to drive down their wages. But in later stages, gains of changing composition of the economy would spread over larger number of people as increased demand for workers improves their wages and consequently they can invest more in human capital. Therefore, in later stages, human capital accumulation takes over the physical capital accumulation thereby becoming the main engine of growth.

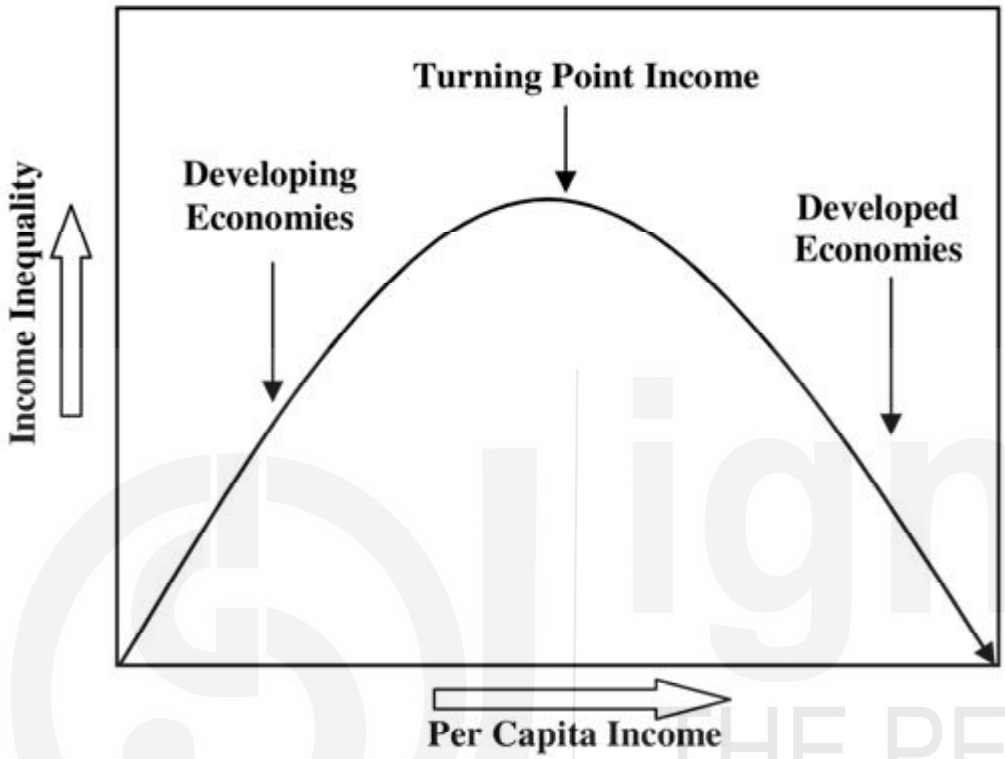

Figure 1.2: The Inverted-U Hypothesis

Using the ratio of the income share of the richest 20 percent of the population to that of the poorest 60 percent of the population, Kuznets established that between 1913 and 1948, income inequality declined in the United States of America. The hypothesis can be tested by using cross-sectional and time series data to get an idea of income inequalities across regions/countries. Using time series data, we can study the income inequality in a region/country over time. Kuznets curve is extended to study the relationship between environmental degradation and economic development. The environmental Kuznets curve shows that in the early stages of economic growth there is an increase in environmental degradation and pollution, but beyond some level of per capita income, the trend reverses.

Income inequalities in the developed as well as emerging economies have increased in recent years. The hypothesis has, therefore, important policy implications. Since inequality and poverty result in poor quality of health, nutrition, education and level of living, it has the potential to create social and political conflicts. This would adversely affect the future development potentials of a country.

1.7 POST-REFORM POVERTY TRENDS IN INDIA

Various Task Forces/Expert Groups have been constituted by the Government of India from time to time to estimate poverty (e.g. Alagh, 1977; Lakdawala, 1989; Tendulkar, 2005; Rangarajan, 2012). There have been improvements in the methodology of

estimation over the period. Table 1.8 presents a comparative profile of the poverty estimates provided by the most recently constituted Tendulkar and Rangarajan Expert Groups. The former used the all-India urban poverty line basket as the reference to derive the state-level (rural and urban) poverty estimates. This was a departure from the earlier practice of using two separate poverty line baskets for rural and urban areas. The Rangarajan Group reverted to the practice of having separate all-India rural and urban poverty basket lines for deriving the state-level rural and urban estimates. It also considered certain non-food expenditures like expenditure on shelter, education, clothing, conveyance and a behaviourally determined level of other non-food expenses. Since it is difficult to set minimum norms for these essential non-food items, the group recommended that observed expenditures on these items by households located in the median fractile (45-50 percentile) be treated as the normative minimum private consumption expenditure on these items. For all other non-food goods and services, the observed expenditure of that fractile-class meeting the nutrient-norms (of the 25th to 30th percentile in rural India, and the 15th to 20th percentile in urban India) was taken to define the poverty line basket in respect of these items. The group, therefore, estimated the MPCE of Rs. 972 for rural areas and Rs. 1407 for urban areas to constitute the poverty lines at the all- India level for 2011-12.

It is thus clear that the methodology used by the Rangarajan group is an improvement over that of the Tendulkar group as it includes both food and essential non-food items in the MPCE to measure poverty. As Table 1.8 below indicates, the poverty estimation by the Rangarajan group is higher than that of the Tendulkar Group. Since poverty is a multi-dimensional concept, inclusion of some non-food items in the poverty estimation is a step towards the computation of multi-dimensional poverty in India.

Table 1.8: Percentage and Number of Estimated Poor

Year	Poverty Ratio (Percent)			Number of Poor (Million)		
	Rural	Urban	Total	Rural	Urban	Total
Tendulkar Group (2009)						
1993-94	50.1	31.8	45.3	328.6	74.5	403.7
2004-05	41.8	25.7	37.2	326.3	80.8	407.1
2009-10	33.8	20.9	29.8	278.2	76.5	354.7
2011-12	25.7	13.7	21.9	216.7	53.1	269.8
Rangarajan Group (2014)						
2009-10	39.6	35.1	38.2	325.9	128.7	454.6
2011-12	30.9	26.4	29.5	260.5	102.5	363.0

Source: Planning Commission, 2009 & 2014.

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

1) Distinguish between 'inequality of opportunities' and 'inequality of outcomes'. What is the role of government in reducing the inequality in societies?

.....

.....

.....

.....

2) Do you think, like poverty, inequality too is multi-dimensional? Why? What is an essential difference between the two (i.e. poverty and inequality)?

.....

.....

.....

.....

3) With the help of the standard diagram for plotting the Lorenz Curve, identify the conditions under which 'greater equality' and 'greater inequality' would prevail in an economy.

.....

.....

.....

.....

4) What does 'Gini coefficient' basically measure? In what way this coefficient and the Lorenz curve are related? How is Gini coefficient measured in empirical exercises?

.....

.....

.....

.....

5) What is meant by 'Pigou-Dalton principle of transfers' in the context of an inequality index?

.....

.....

.....

.....

6) How does the Kuznets' 'inverted-U hypothesis' characterise the relationship between 'economic growth' and 'economic inequality'? What are the main reasons attributed for this trend? What are the policy implications of this hypothesis?

.....

.....

.....

.....

7) What are the basic differences in the methodological framework adopted by the two most recent Expert Groups constituted to provide estimates of poverty in India? Which one of the two is better and why?

.....

.....

.....

.....

1.8 LET US SUM UP

The unit outlines the circumstances under which government's intervention is absolutely required under conditions of market economy. Two specific situations discussed in this context are poverty and inequality, both of which would act as severe constraints in the path of growth and development in a society. Various techniques of measurement of both are discussed in the unit. Kuznets's hypothesis which suggests that inequality, in the process of growth, would initially rise but subsequently declines is then discussed. The unit ends by presenting the post-reform poverty trends in India.

1.9 KEY WORDS

Poverty : Refers to a lack of access to minimum standard of living in a society. Poverty can be either absolute or relative. Absolute poverty refers to the minimum basic needs of human beings, such as, food and nutrition, clothing, shelter and preventive and protective healthcare, necessary for their survival and physical health. Relative poverty is talked of in terms of a 'poverty line' which is an explicit function of the income distribution – namely, a constant fraction of some income standard. It interprets poverty in relation to the prevailing standards of the society at the time.

Poverty Line : The poverty line is a monetary measure of the minimum consumption of goods and services that a household should obtain in order to ensure that its basic needs are adequately met.

Poverty Gap : It is the average of the differences between the income of each individual poor and the poverty line. It measures the total amount of income necessary to raise everyone who is below the poverty line up to that line.

Inequality : Represents a situation where income is not distributed equally amongst people. Like poverty, inequality also has two dimensions: inequality of opportunities and inequality of outcomes. The former exist in any society due to differences in individual circumstances that are beyond the control of individual (e.g. gender, caste, parental education, etc.). Such inequalities reflect the institutional weaknesses and social exclusion and are to be targeted through affirmative policy actions. Inequality of outcome exists due to differences in the individual efforts in availing the opportunities.

Kuznets' Curve : Represents a hypothesis which argues that in the initial phase of economic growth, inequalities will rise but subsequently declines.

Gini Coefficient : Gives a number, ranging between 0 and 1. A greater value of Gini coefficient implies higher inequality.

1.10 SUGGESTED REFERENCES FOR FURTHER READING

1. Planning Commission (2009), Report of the Expert Group to Review the Methodology for Estimation of Poverty, Government of India, New Delhi.
2. Planning Commission (2014), Report of the Expert Group to Review the Methodology for Measurement of Poverty, Government of India, New Delhi.
3. Alkire, Sabina and James Foster. (2011), "Understandings and Misunderstandings of Multidimensional Poverty Measurement." The Journal of Economic Inequality, 9(2), 289-314.
4. Sen, A. (1997), On Economic Inequality, New York, Oxford University Press.
5. Haughton J. and Khandker, S.R. (2009), Handbook on Poverty and Inequality, World Bank, Washington, DC.

1.11 ANSWERS/HINTS TO CHECK YOUR PROGRESS QUESTIONS

Check Your Progress 1

1) See 1.2 and answer.
2) See 1.2 and answer.
3) See 1.3 and answer.
4) See 1.3 and answer..
5) See 1.3 and answer.

Check Your Progress 2

1) See 1.4 and answer.
2) See 1.4 and answer.
3) See 1.4 and answer.
4) See 1.4.1.1 and answer.
5) See 1.4.1.2 and answer.
6) See 1.4.1.3 and answer.
7) See 1.4.2 and answer.
8) See 1.4.3 and answer.

Check Your Progress 3

1) See 1.5 and answer.
2) See 1.5.1 and answer.
3) See 1.5.1.1 and answer.
4) See 1.5.1.2 and answer.
5) See 1.5.2 and answer.
6) See 1.6 and answer.
7) See 1.7 and answer.

UNIT 2 ECONOMY AND ENVIRONMENT

Structure

2.0 OBJECTIVES

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

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

2.1 INTRODUCTION

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

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

2.2 ECONOMY-ENVIRONMENT INTERACTION

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

2.2.1 Circular Flow/Material Balance

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

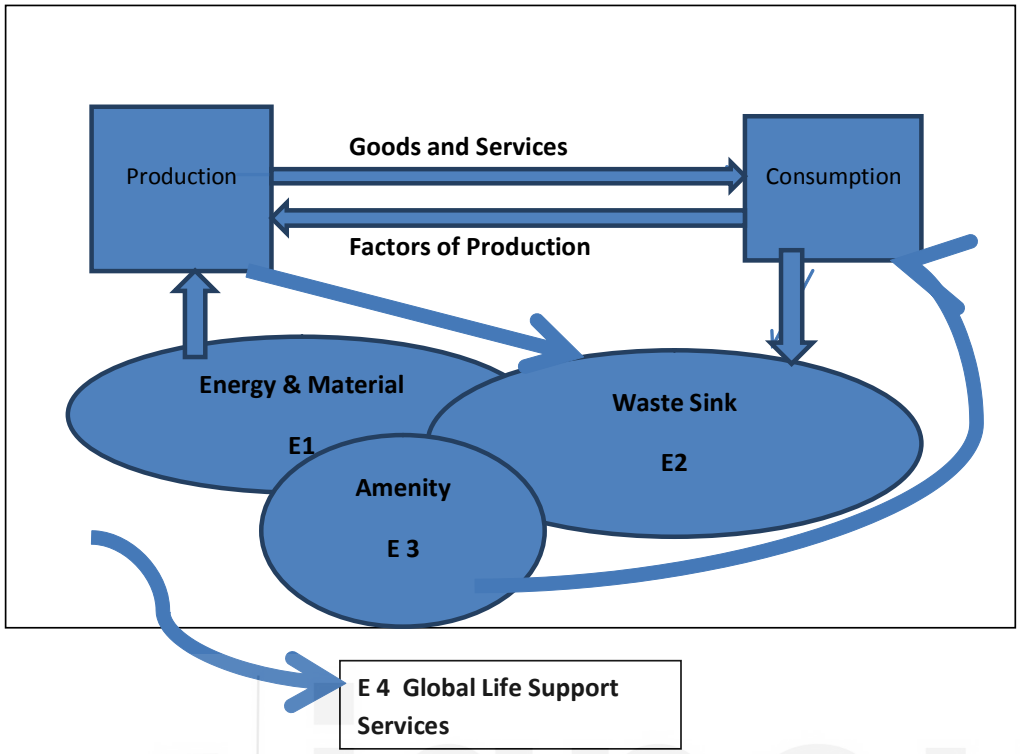

Figure 2.1: Circular Flow Diagram

as a *supplier of resources* where it provides the economy with **raw materials**, which are then transformed into consumer products by the production process with **energy** fuelling the transformation. Its second role is as a **sink** or receptor for waste products. The natural environment functions as the ultimate repository of waste products generated in which gaseous substances like CO_2 and SO_2 go to the atmosphere, industrial and municipal sewage go into rivers and seas, solid waste goes to landfill, chlorofluro-carbons go to the stratosphere and so on. Besides these, the natural systems themselves generate waste like trees shedding off their leaves. However, the basic difference between the waste generated by the two systems (natural and man-made) is that while the natural system tends to recycle their waste (like the dried leaves naturally decomposed in the soil and converted into organic fertilizer for plants and the trees), the waste generated by the economic systems does not have such inbuilt system to absorb the waste by recycling. So the wastes are released into the environment. The environment, however, has a capability limit to absorb the waste and convert them back into harmless or ecologically useful products. This is called the environment's **assimilative capacity** or the **carrying capacity,** which is the second major function of natural environment. The assimilative capacity of the environment is thus a resource which is finite. So long as we dispose of waste in quantities (and qualities) that are commensurate with the environment's assimilative capacity, the economic system will function just like a natural system. But if the disposal exceeds the assimilative capacity we begin witnessing its external manifestation broadly called as **pollution**. We thus have air pollution, water pollution, forest degradation, soil contamination, etc. Excessive waste, when it crosses the assimilative capacity of nature, depreciates the assets or resources by way of reducing their efficiency of service that they otherwise provide. It then starts yielding negative externalities like respiratory problems (caused by air pollution), gastrointestinal diseases (caused by drinking polluted water), nature's beauty getting restricted by smog, etc. The smog effect on nature relates to the third service the environment provides us by way of a wide range of ***aesthetic amenity of spiritual and educational value to the society*** (e.g. majestic mountains, serenity of the wilderness trek, adventure of the

wild life sanctuary, mesmerizing view of sunset in the sea) for which no substitutes exist. If we generate more waste, in excess of assimilative capacity of the environment, it will degrade this important function of the environment (e.g. polluted river detracting the amenity value of water flow in the environment). We can look at this from the 'utility-environmental resource-goods/service' perspective as follows.

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

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

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

2.2.2 Laws of Thermodynamics

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

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

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

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

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

2.2.3 Life Support System and Sustainability

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

underlying the economy. But if we are interested in sustaining an economy, it is important to establish the sustainability conditions for the compatibility of economies and their environments.

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

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

2.3 MARKET FAILURE IN THE CONTEXT OF ENVIRONMENTAL GOODS

A market is an institution which help agents (buyers and sellers) to exchange goods, services and information through price mechanism. It is a process by which the prices of goods and services are established. Markets facilitate the distribution and allocation of resources in a society. Markets thus use prices to communicate the wants and limits of a diffuse and diverse society so as to bring about coordinated economic decisions in the most efficient manner. The power of perfectly functioning market rests in its decentralized process of decision making and exchange with no omnipotent central

planner needing to allocate resources. Rather, prices ration resources to those who value them the most to achieve what is best for the society as a collective. Optimal private decisions based on mutually advantageous exchange lead to optimal social outcomes.

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

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

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

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

Theoretically, the ideal benchmark for an efficient allocation of resources is the perfectly competitive market, where private decisions lead to social optimum. Given this, we can explore how the perfect market benchmark misfires to specifically lead to violation

of ideal conditions leading to market failure. These are stated in terms of: (i) non-exclusion; (ii) non-rival consumption; (iii) incomplete market; (iv) externalities; (v) non-convexities; (vi) asymmetric information; and (vii) public goods/bads. One important form of market failure, not considered here, relates to non-competitive behaviour such as monopoly power, as it is not generally associated with environmental assets.

2.3.1 Non-Excludability

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

2.3.2 Non-Rivalry

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

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

2.3.3 Externality

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

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

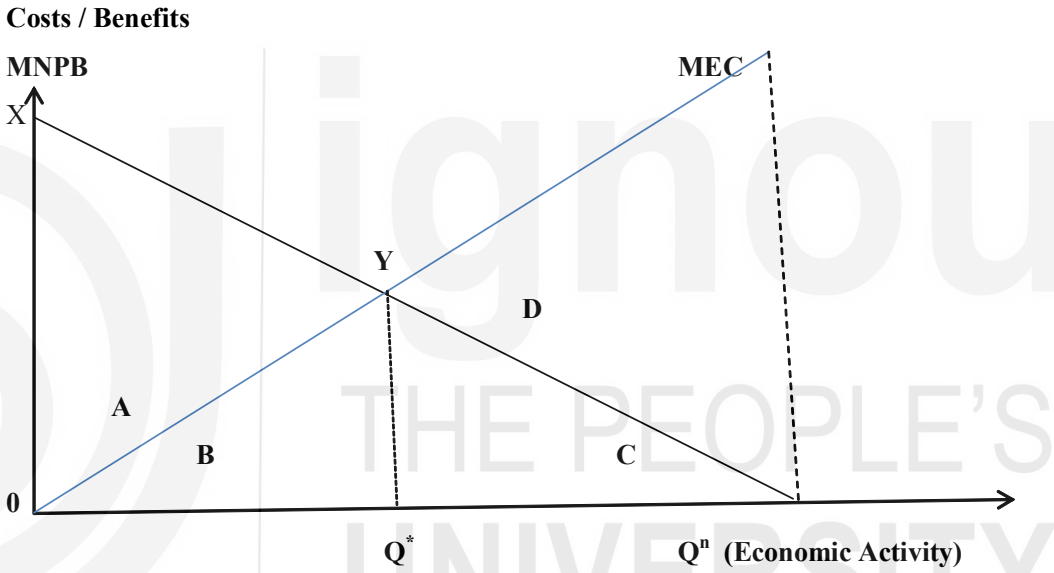

Figure 2.2: Economic Definition of Optimal Pollution

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

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

Thus, P – MC = MEC

Or, P = MEC + MC = MSC

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

2.3.4 Incomplete Market

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

2.3.5 Non-Convexities

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

2.3.6 Asymmetric Information

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

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

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

2.3.7 Public Goods and Bads

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

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

Figure 2.3: Distinction Between Pure and Impure Public Goods

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

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

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

2.4 PROPERTY RIGHTS VERSUS COMMON PROPERTY

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

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

A common-pool resource, also called a common property resource (CPR), is a type of good consisting of natural or human-made resource system (e.g. an irrigation system or fishing grounds), whose size or characteristics makes it costly (but not impossible), to

exclude potential beneficiaries from its use. Unlike pure public goods, due to rivalry, common pool resources face problems of congestion or overuse. A common-pool resource typically consists of a core resource (e.g. water or fish), which defines the stock variable, while providing a limited quantity of extractable fringe units, which defines the flow variable. While the core resource is to be protected or nurtured in order to allow for its continuous exploitation, the fringe units can be harvested or consumed. Examples of common-pool resources include irrigation systems, fishing grounds, pastures, forests, water or the atmosphere. A pasture, for instance, allows for a certain amount of grazing to occur each year without the core resource being harmed. In case of excessive grazing, the pasture may become more prone to erosion and eventually yield less benefit to its users. Because their core resources are vulnerable, common-pool resources are generally subject to the problems of free-riding leading to congestion, overuse, pollution, and potential destruction unless harvesting or use limits are devised and enforced. Free-riding can lead to what is commonly called the classic case of the prisoner's dilemma, also called *tragedy of the commons* (dealt with it in detail in Unit 15). The dilemma exists when people find that their individual incentives lead them to the worst outcome possible – both for themselves and the society.

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

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

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

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

2.4.1 Coase Theorem

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

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

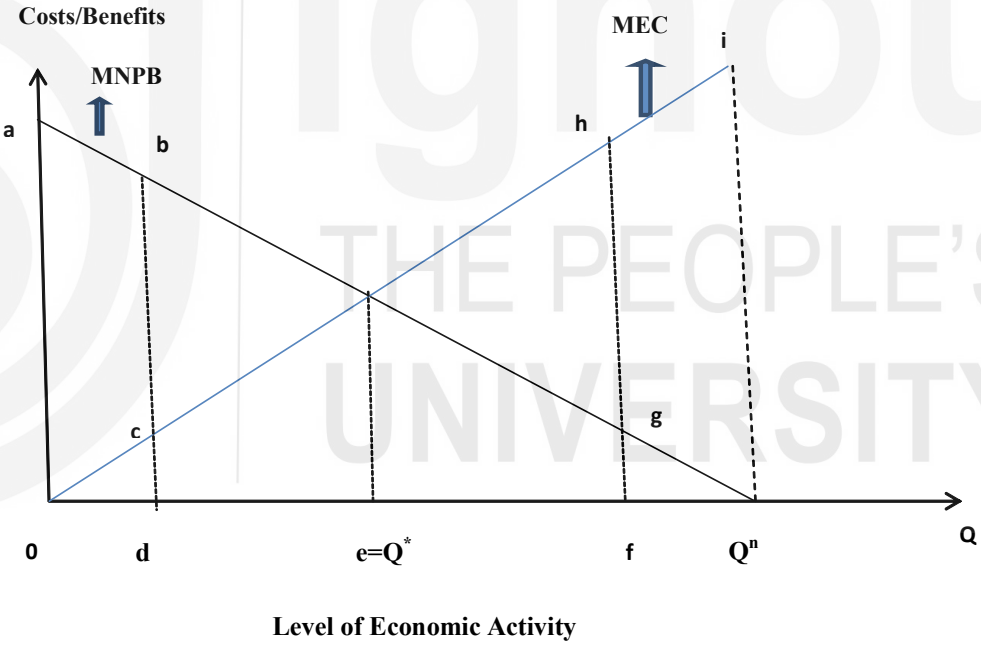

Figure 2.4: Economic Definition of Optimal Pollution

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

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

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

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

2.4.2 Limitations of Coase Theorem

Recall that MNPB is defined as :

MNPB = P – MC

and the socially optimal level of pollution occurs where,

MNPB = MEC.

Thus, the above two equations entail:

P = MC + MEC = MSC

Under competitive situation, it is assumed that the MNPB is the polluter's bargaining curve. However, if perfect competition does not prevail, then (P – MC) is no longer the bargaining curve, because it is no longer equal to MNPB. If the polluter is a firm, it should be fairly evident that his bargaining curve is his 'marginal profit curve' and, under imperfect competition, this is equal to 'marginal revenue' minus 'marginal costs' i.e. MNPB = MR – MC. Under imperfect competition, MR is not equal to P because the

demand curve is above the marginal revenue curve. It thus follows that the bargaining solution does not apply under imperfect competition. The existence of imperfect competition provides the basis for a serious critique of the Coase theorem.

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

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

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

Income effect

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

Identifying the bargaining parties

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

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

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

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

2.5 FUTURE TIME PREFERENCE AND DISCOUNT RATE

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

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

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

of preference; and (v) it allows us to emphasize both the economic value of environmental protection as well as the opportunity cost of protecting the environment.

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

2.5.2 Discounting of Cost and Benefit Flows

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

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

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

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

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

The debate about discounting the future in public investment is accentuated by environmental problems like biodiversity loss, ecosystem disruption and climate change. All these problems are bound to have long-term impacts which will affect us as well as future generations. Hence, there is a concern for intergenerational equity. Thus, how much should our current generation invest? Should we sacrifice a part of our well-being

for the benefit of future generations? This is dependent, among other things, on the inter-temporal preferences (and thus discounting of public investment) of the current generation. If we discount the investments in biodiversity conservation and climate change mitigation, the benefits of our investments for future generations will appear smaller in present value terms. This would foster a state of 'low inter-generational equity' where the wellbeing of different generations (including those yet to be born) would be unequally valued. In this context, the concept of **Social Discount Rate** reflects a society's relative valuation on today's well-being projected into the future. The appropriate selection of a social discount rate is crucial for cost-benefit analysis since it has important implications for resource allocations. There is wide diversity in social discount rates with the developed nations typically applying a lower rate than the developing nations.

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

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

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

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

2.5.3 Importance of Discount Rate for Global Climate Change

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

economists arguing that giving future generations less weight than the current generation is 'ethically indefensible.'

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

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

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

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

2.6 LET US SUM UP

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

2.7 KEY WORDS

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

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

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

Entropy : Amount of energy not available for work.

Externalities : Refers to economic activities causing an adverse impact on a third party but suffer on account of receiving no compensation from either of the parties for the losses suffered. While the adverse

situation refers to negative externalities, externalities can be positive too.

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

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

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

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

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

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

Open Access Resources : The resources owned by nobody.

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

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

2.8 SUGGESTED REFERENCES FOR FURTHER READING

1. Bhattacharya, Rabindranath (2002), Environmental Economics (ed.), Oxford University Press.

2. Dasgupta, P (1982), The Control of Resources, Oxford: Blackwell.

3. Global Energy Assessment (GEA) (2012), *Towards a Sustainable Future,* Cambridge University Press and The International Institute for Applied Systems and Analysis (IIASA), 2012.

4. Hanley, Nick, Jason F. Shogren and Ben White (2001), Introduction to Environmental Economics, Oxford University Press (India).

5. IPCC (2014), Climate Change 2014: Synthesis Report – Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland.

6. Kolstad, Charles D (2000), Environmental Economics, Oxford University Press.

7. Sengupta, Ramprasad (2013), Ecological Limits and Economic Development, Oxford University Press, New Delhi.

8. Pearce, David W., and R Kerry Turner (1990), Economics of Natural Resources and the Environment, Harvester Wheatsheaf.

9. Tietenberg, Tom (2003), Environmental and Natural Resource Economics, Pearson Education.

2.9 ANSWERS/HINTS TO CHECK YOUR PROGRESS QUESTIONS

Check Your Progress 1

1) See 2.2 and answer.

2) See 2.2 and answer.

3) See 2.2 and answer.

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

5) See 2.4 and answer.

6) See 2.4 and answer.

7) See 2.4.1 and answer.

8) See 2.4.1 and answer.

Check Your Progress 2

1) See 2.3 and answer.

2) See 2.3 and answer.

3) See 2.3.1 and answer.

4) See 2.3.2 and answer.

5) See 2.3.3 and answer.

6) See 2.3.3 and answer.

7) See 2.3.4 and answer.

8) See 2.3.5 and answer.

9) See 2.3.6 and answer.

10) See 2.3.7 and answer.

Check Your Progress 3

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

Check Your Progress 4

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

UNIT 3 SOCIETY AND ENVIRONMENT

Structure

3.0 OBJECTIVES

After reading this unit, you will be able to:

- discuss the analytical framework in which poverty-environment interactions are embedded;
- describe the impact of environmental degradation on poor with its implications for conservation of natural resources;
- explain the factors that links population and environment;
- state the common policy objectives for addressing the population-poverty-environment interface;
- analyse the theory of 'affluence' in relation to post-materialistic value hypothesis;
- specify the formulation of IPAT and KAYA identities;
- delineate the major considerations involved in the reformulation of IPAT;
- critique the different methodological frameworks adopted in the population focused studies for estimating the IPAT coefficients;
- illustrate Commoner's application of the IPAT framework to agriculture; and
- indicate the direction in which future work on assessing the environmental impact on society should proceed.

3.1 INTRODUCTION

Principles of 'inclusive development' requires focusing on the development of the poorer and other marginalised sections of the society. Studies have shown close positive relationship between the lifestyles of the poor and environmental conservation. In one of the conclusions of the Bruntland Commission report (which has been accepted as the blueprint for environmental conservation), it is explicitly stated that poverty is a major cause of environmental problems and amelioration of poverty is a necessary and central condition of any effective program to deal with environmental concerns. Beyond the concerns of 'sustainable development', protecting the present means of lifestyle sustenance of the poor itself demand both conservation and efficient utilisation of available environmental resources. These priorities often clash with the requirements of economic growth which makes the poor particularly more vulnerable on account of the exploitative tendencies of the more powerful on the one hand and their own limitations for protecting their interests on the other. Timely inaction (or inadequate action) on the part of the governments result in 'market failure' and sub-marginalisation of the poor. In the face of these hard realities, the present unit discusses the issues and linkages on two fronts viz. 'poverty and environment' and 'population and environment'. In respect of the latter, the hypothesis of 'whether there is enough evidence to support the claim that population growth (or its dynamics) results in (or contribute to) environmental degradation' is examined. Two main empirical formulations viz. IPAT and KAYA, both identities defined in terms of three key determinants viz. population, affluence and technology (impacting environment) are discussed. Within this, many methodological approaches are outlined so as to provide a critical appraisal of their findings including further work needed to be undertaken to generate more empirical backing to the contentious views involved.

3.2 POVERTY AND ENVIRONMENT

There has been a vast literature on "poverty–environment nexus' referring to a set of mutually reinforcing links between poverty and environmental damage. In this, poverty reduction and environmental protection have often emerged as complementary goals. The nexus concept is provided as a defence against environmental damage argument. This is based on the 'Environmental Kuznets Curve' which states that in the early stages of development there is an unavoidable conflict between poverty reduction and environmental protection. The general consensus, during the intervening period of development, is that poverty is a major cause of environmental degradation. In fact, both poverty and environmental degradation have been increasing in many developing countries. In view of this, there is an urgent need to first evaluate and analyze the poverty-environmental degradation nexus and, second, to prescribe policy options to mitigate or eradicate both these problems.

The interaction between poverty and environment is explained by a flow diagram (Figure 3.1). The diagram relates four blocks of variables viz. (i) assets of the rural poor; (ii) household behaviour pertinent to environment-poverty links (e.g. income generation, investment, consumption); (iii) categories of natural resources (soil, water, etc.); and (iv) conditioning variables (e.g. market, prices, etc.). The asset categories of poverty affect household and village behaviour, which in turn affects the (quality and quantity of) natural resources as well as household/village assets. The conditioning variables influence the links between the types of poverty and behaviour, as well as the links between behaviour and natural resources.

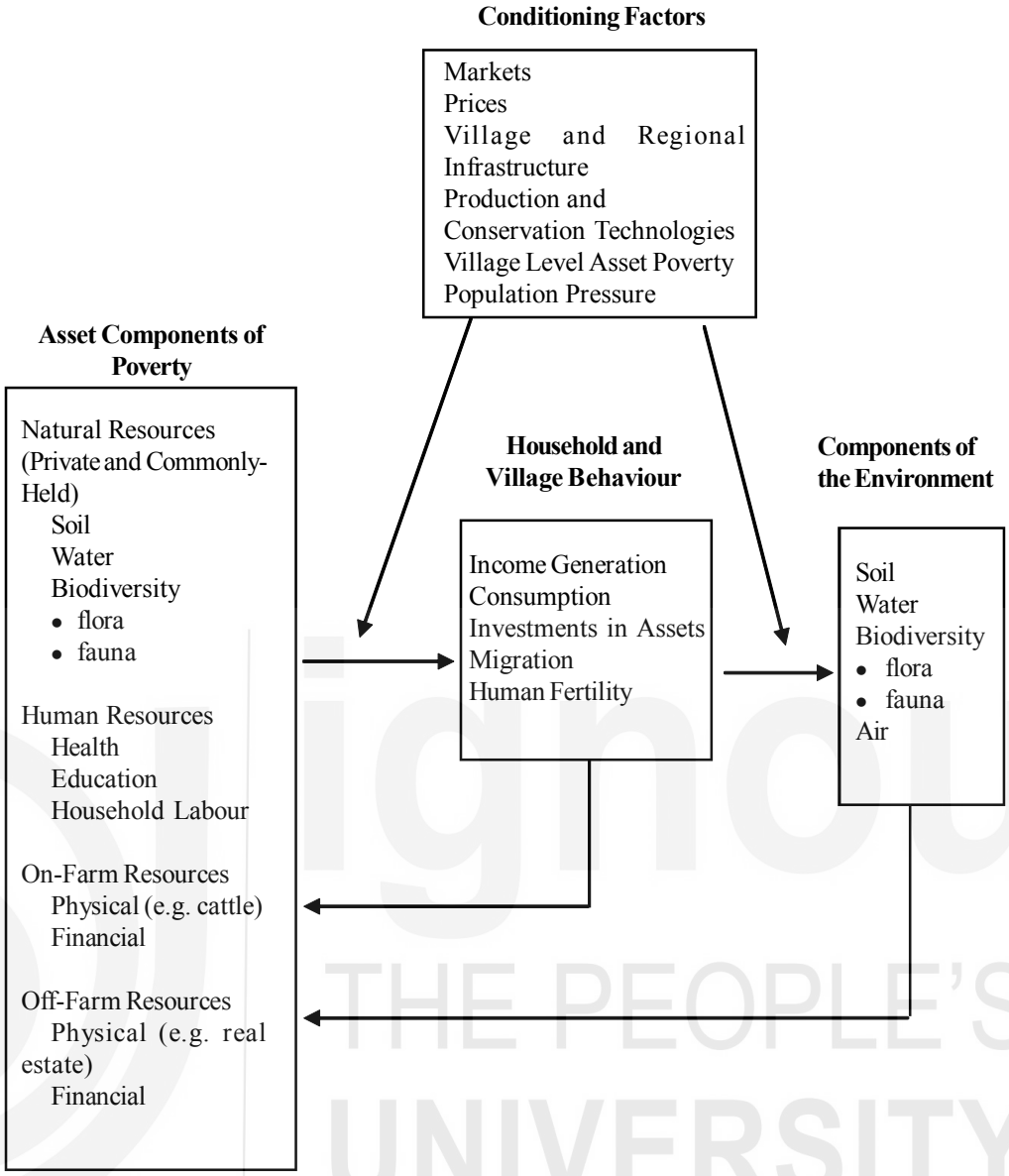

Figure 3.1: Poverty and Environment Changes

Source: Reardon and Vosti (1995)

3.2.1 Analytical Framework

Since the late 1980s, it has been widely accepted that the interaction of agricultural development with the environment must be explicitly considered, both to ensure the long-term sustainability of production systems and to mitigate the negative effects on the local and the globally important ecological goods and services (an approach called by Conway (1997) as the 'double-green revolution'. Since environmental degradation in turn leads to issues of (or negative consequences of) declining consumption, human health and food security, the following three situations could be logically construed to arise: (a) no environmental degradation; (b) no endogenous poverty; and (c) the possibility of the existence of exogenous poverty. Endogenous poverty is here defined as poverty caused by environmental degradation while exogenous poverty is defined as poverty caused by factors other than environmental degradation. It is, therefore, clear that condition (b) follows from condition (a). In light of this, possible relations in poverty-environmental degradation nexus can be construed in terms of the following analytical framework.

- Exogenous poverty → environmental degradation
- Power, wealth and greed → environmental degradation
- Institutional failure → environmental degradation
- Market failure → environmental degradation
- Environmental degradation → environmental degradation (in the sense that once environmental degradation sets-in, there is likely to be continued environmental degradation for some time till it is reversed by proactive policies)
- Endogenous poverty → environmental degradation

In view of this, to break the nexus between environmental degradation and poverty all of the left-hand side factors needs to be simultaneously focused upon with institutional and policy mechanisms.

3.2.2 Impact of Environmental Degradation on the Poor

The poor's exposure to environmental degradation is distinctive for two reasons. First, locations inhabited by the poor are often environmentally vulnerable or degraded (e.g. urban slums with inadequate water and sanitation facilities are often most vulnerable to severe health hazards). Second, being poor entails a lack of means to avoid the impacts of environmental degradation i.e. a lack of resources makes it difficult for the poor to buy out from their exposure to environmental risks (by investing in alleviating the causes of environmental degradation as the non-poor can do). In light of this, the following two hypothetical situations would arise.

H_1: Pollution Damages the Health of the Poor: Several types of pollution have the most pervasive and serious consequences for the health of the poor. In order of severity, the most important is pollution of water for disease causing vectors rendering the poor vulnerable to infectious and parasitic illnesses. Second is indoor air pollution from the use of biomass as a household energy source, principally in rural areas. Third is outdoor air pollution, which is mostly an urban problem.

H_2: Environmental Degradation Lowers the Poor's Productivity: In addition to affecting their health and capacity to work, environmental degradation depresses the poor's ability to generate income through two channels: first, it requires the poor to 'divert an increasing share of their labour' to routine household tasks such as fuel wood collection; and second, it also 'decreases the productivity of those natural resources' from which the poor wrest their livelihood. Moreover, environmental degradation can lower the labour productivity of the poor even when they are healthy. For instance, as fuel-wood becomes scarce, poor households must spend an increasing amount of time in collecting it. Where family labour is not abundant, greater time is spent on fuel-wood collection reducing the time available for other productive activities resulting in lower incomes. Further, environmental degradation reduces the productivity of natural resources thereby perpetuating impoverishment. Productivity declines of this kind are caused by a number of factors, some of which are beyond the control of the common people. Examples include: (i) destruction of inland and coastal fisheries by industrial water pollution and municipal sewerage; (ii) degradation of wetlands and flood plain soils as a result of upstream dam construction; (iii) deforestation by settlers, loggers, and ranchers destroying the livelihoods of indigenous forest dwellers and exposing them to the risk of uncertain incomes.

More frequently, productivity decline is more intricately related to the poverty-

population-environment interaction. Where the poor depend on biomass fuel and confront increasing fuel-wood scarcity, they often shift to using animal dung, fodder, and crop residues for fuel. Because reduced quantities of these materials are returned to the soil, fertility of soil declines. Where rural population growth is putting pressure on land resources such that fallow periods are shortened, poverty may constrain farmers' ability to maintain soil productivity through more intense application of variable inputs. The productivity of open access natural resources or of resources under deteriorating common property management often declines because of over-use.

3.2.3 Impact of Poverty on Resource Management

The following two hypothetical propositions can be put forward in this regard: Poverty Imposes Short Time Horizons (H_1); and Risks Further Contribute to the Poor's Short Term Focus (H_2). The very poor, struggling at the edge of subsistence levels of consumption, are pre-occupied with survival on a day-to-day basis. The ability to plan ahead is often restricted to a critically short time horizon, measured in days or weeks. But these short time horizons should not be viewed as an innate characteristic of the poor, but rather the consequence of complex interactions among policy, institutional and social failures. Under most circumstances, people tend to be risk averse, preferring to trade some of the value for potential outcome for a greater certainty of its happening. To the extent that outcomes become less certain (i.e. the more distantly in the future they are), risk aversion tends to imply a preference for outcomes that will happen sooner. Studies on risk and farmers in India (e.g. Binswanger, 1989), Central America (e.g. Walker, 1981), Thailand and the Philippines have confirmed the predominance of risk aversion, albeit with a great deal of heterogeneity. The results also suggest that in their attitude to risk the poor are not distinguished from the non-poor by innate or acquired characteristics such as education. Rather, in this regard, poor farmers are distinguished by their higher levels of risk and greater constraints to coping with that risk.

Check Your Progress 1 [answer the questions in about 50 words in the space given]

1) What is 'poverty-environment nexus'? In what way, Kuznets's postulation offers defence against environmental damage arguments for developing economies?

.....

.....

.....

.....

2) What are the factors that need to be focused upon in order to break the poverty-environment nexus?

.....

.....

.....

.....

3) State the two hypotheses that emerge from the vulnerability of the poor to the consequences of environmental degradation.

.....

.....

.....

.....

4) Illustrate with examples how productivity declines of poor could be a consequence of market failure.

.....

.....

.....

.....

5) Do you unconditionally agree that 'poverty imposes short time horizons' on the poor? Explain.

.....

.....

.....

.....

6) Is it true that the poor are more vulnerable in their attitude to risk aversion? What do the results of the study across countries reveal in this respect?

.....

.....

.....

.....

3.3 POPULATION AND ENVIRONMENT

The dynamics of population potentially exacerbates the impact of other factors such as poverty, inadequate property rights and consumption levels on environmental degradation. The impact intervenes along three main dimensions: (i) its scale in relation to the resource base; (ii) its rate of growth; and (iii) its redistribution across resources through migration. Population's impact on the environment is critical in some countries or regions within countries, but is less important in others. Moreover, the three dimensions will not be equally important for the environment in different places and points in time. Thus, assessments of population's impact on the environment, and the appropriateness of addressing such impact through direct population interventions, need to take local circumstances into account. Once again, we can perceive the impact on vulnerable sections of the population in terms of the following two propositions.

***Poverty and Environmental Feedbacks*:** Sustained economic growth leads to decreasing incremental per capita emissions of pollution after a certain critical point. But it is not good enough to avert potential environmental crisis of global proportions.

***Poverty and Common Property Resources*:** Environmental damages tends to affect the poor particularly severely as they heavily rely on fragile natural resources for their livelihood. Although in normal situations returns on natural capital are greater than on

the human capital, polluted areas being cheap or free, the poor choose to reside there as squatters. Because of their status as squatters, access to safe drinking water and sanitation is usually denied in the first instance and provided later (due to political compulsions) after long gap of time. Regarding poverty and deforestation, lessons from Mexico and Indonesia indicate that export-oriented tree crops play an important role in deforestation relative to shifting cultivation.

3.3.1 Factors Explaining Population and Environment Linkages

Three key factors can be pointed out to explain the dynamics of population-environment linkages.

***Local Endowments*:** The impact of natural resource change in agricultural environments has the potential to influence the bio-physical conditions of a region. This happens by the changing relationship between population growth and natural resource availability. Key factors which bring about these changes are: (i) soil characteristics (affecting crop choice, cropping frequency and input use); (ii) rainfall and consequently the ground and surface water resources (affecting crop product choice, risks of soil degradation and land use intensity); and (iv) topography of land (affecting the spatial distribution of production systems). Further, landscape differences and resource management challenges would also arise from variations in settlement history, past history of degradation, crop mix and quality of livestock products. All these factors would together bring about variation in the mix of commercial and subsistence enterprises in the region.

***Use of Resource-Conserving Technology*:** Researchers have demonstrated that poor farmers, in the absence of systematic assistance, end up adopting such resource-conserving practices which are often less efficient. Although such practices also contribute to some amount of increased productivity or output stability, they are generally an economic threat to the viability of farmers' interest in the face of growing risk of depleting natural resource stock. In such situations, use of dual-purpose resource conserving technologies are essential to achieve poverty reduction on the one hand and environmental protection objectives on the other. By determining the distribution of physical and social infrastructure between rural and urban sectors, large and small farmers, etc. implementation of suitable public investment policies would enhance the comparative advantage of poor farmers in agricultural production and small service enterprises.

***Institutions Supporting the Interests of the Poor*:** Local institutions often strengthen the social fabric within which the dynamics of poverty–agriculture–environment interactions are determined. Effective resource management, whether of private, communal or public resources, often requires collective regulation (e.g. use or management restrictions on privately-held resources to influence environmental externalities) and collective investment (e.g. establishment of community drainage systems or trees for public use) strategies. Good local organisational and management skills often underpin the success of such resource management activities. Cultural, demographic, market and leadership factors together act as institutions to protect the local resource base.

3.3.2 Population-Poverty-Environment Interface: Policy Implications

The environmental needs of, and pressures on, poor farming communities will certainly intensify in coming decades. Although the relationship between population-poverty-

environment interface is dynamic, the 'downward spiral' is both avoidable and reversible in many circumstances. Poor people have an unrecognised potential for adaptation and innovation. Public policies can positively influence the micro-scale factors that determine how farmers adapt to environmental pressures. However, more pro-active policies are required to achieve environmental and anti-poverty objectives simultaneously, enhancing the access to and productivity of poor people's natural resource assets and engaging them as partners in public resource management. Research efforts and methodologies to support such policies are yet in a formative stage. To reiterate, therefore, the common objectives of environment protection and tackling the poverty of poor dependent on natural resource endowments should focus upon the following.

1. Increase poor people's access to natural resources essential to their livelihoods.
2. Work with the poor to increase the productivity of the natural resources so that they can take advantage of existing or emerging economic opportunities. This can be by way of co-investing in on-farm natural resources of the poor, promoting agricultural technologies with environmental benefits and promoting low-risk production in poor and marginal areas, etc. and
3. Involve the poor in promoting good environmental management practices under conditions when economic incentives for doing so are not in place. This can be done by compensating the poor for conserving or managing resources important to others i.e. by employing the poor to improve the public natural resources.

Check Your Progress 2 [answer questions in about 50 words in the space given]

1) Why is it important to consider local circumstances while assessing the impact of population dynamics on environmental degradation?

.....

.....

.....

.....

2) What are the key factors responsible for bringing about the desired changes between population growth and natural resource availability in agricultural environments?

.....

.....

.....

.....

3) In what way public investment strategies could be of help in enhancing the comparative advantage of poor farmers?

.....

.....

.....

.....

4) How can local institutions strengthen the regional natural resource base thereby contributing to protecting the interests of the poor?

.....

.....

.....

.....

5) What are the common objectives on which policy focus is needed to achieve all round improvement in respect of poverty alleviation and environment protection?

.....

.....

.....

.....

3.4 AFFLUENCE AND ENVIRONMENT

The idea that population growth affects environmental resources and human welfare is as old as civilization or written history. In view of this, the idea of a causal link between concern for natural environment and increasing population pressure has also been equally old. The various UN resolutions and Protocols like – Convention on Climate Change, the Kyoto Protocol, Intergovernmental Panel on Climate Change reports, etc. have all raised global awareness on anthropogenic climate change. Likewise, numerous grassroots movements, environmental non-governmental organizations, books & documentaries, etc. have focused on the myriad of environmental issues facing citizens around the world. The question that, therefore, arise is: does a nation's level of affluence have a causal impact on individual-level environmental concern within that nation? Towards this, we begin by looking at some of the theoretical postulations.

3.4.1 Theory of Affluence and Exposure to Degradation

A common assumption regarding environmental concern is that only those who are affluent enough to care about concerns beyond immediate survival are able to devote energy to environmental problems and to engage in actions that demonstrate such concerns. These assumptions are supported by the presence of green parties and environmental group memberships in affluent nations with an emphasis on development aid (as opposed to environmental protection assistance) to the countries of the Global South. Such an attitude has, however, been met with serious resistance as they not only limit development but also ignore issues of global inequality. However, with the rise in environmental awareness in the Global South across classes, with transnational environmental movements, the existing explanations of environmental concern as related to 'affluence in some instances and degradation in others' have needed a relook to capture transitions in and nuances of environmental concern across the globe.

One of the main affluence theories is that of Inglehart's post-materialist values. The theory posits that in the past, societies and individuals had to remain focused on survival. However, with the rise of the welfare state and the economic growth of advanced industrial and post-industrial societies, survival needs have yielded to concern for environment, freedom of expression and choice. Going by this sequence, if the post-materialist values hypothesis requires first affluence, and then to acquire environmental

concern, the Global South cannot be explained by post-materialist values because many of these societies have not undergone the transformation Inglehart identifies. Dunlap, therefore, argue that the emergence of widespread concern for environmental quality in non-industrialized nations poses an anomaly as these nations have yet to experience the economic security needed to generate the post-materialist values. Others (e.g. Dunlap and York, 2008) have also found evidence against the 'affluence hypothesis' at the national level and the 'affluence-based post-materialist values' at the individual level. The 1992 Health of the Planet (HOP) survey found that national affluence correlates inconsistently with environmental concern. In response to the growing environmental concern in the Global South among members of all classes Inglehart, therefore, coined the alternative 'objective problems subjective values (OPSV)' hypothesis to explain that people who have more direct exposure to environmental problems could also be more willing to act for environmental causes. Public support for environmental protection policies is, therefore, stimulated by two completely different types of factors. The result is that, in global perspective, neither high pollution levels nor high levels of post-materialism have a significant impact on public support for environmental protection. However, it is only by analytically disentangling their joint effects the importance of either factor can be accorded greater cognizance. Here, Inglehart implies that data for countries of varying levels of affluence should be separately analysed in order to see significant effects of affluence or degradation manifesting in environmental concern. A reasonable criticism of these arguments is, therefore, that they are difficult to test empirically as they are not falsifiable and as it is they are positioned to explain environmental values differently (i.e. with affluence explanations limited to the Global North and exposure to degradation explanation limited to the Global South). Not only is this a problem with the structure of the two theoretically derived hypotheses, but it is also a problem because affluent societies also experience environmental degradation and citizens of less affluent societies could be concerned about the environment even without direct exposure to degradation.

3.4.2 IPAT and KAYA Identities

The vehicle used to begin the discussion of technological change, though phrased mathematically, is largely a conceptual expression of what factors create environmental impact in the first place. The equation used represents environmental impact (*I*) as the product of three variables: population (*P*); affluence (*A*); and technology (*T*). That is:

Impact = Population × Affluence × Technology (called the IPAT equation) where affluence (or consumption) is measured as gross domestic product (GDP)/population, and technology as impact/(population × affluence). The genesis of IPAT equation and related developments could be traced to the environmental movement around 1970. Although first used to quantify contributions to un-sustainability, the formulation has been reinterpreted to assess the most promising path to sustainability. The revisionism can be seen as part of an underlying shift among many environmentalists in their attitudes toward technology. This simple equation emphasizes the verity of multiple drivers of environmental change whose effects are multiplicative.

Yoichi Kaya (and other collaborators) further developed an essentially identical equation to investigate the drivers of greenhouse-gas emissions as:

Total emissions = population × (GDP/population) × (energy/GDP) × (emissions/energy)

i.e. **Total emissions = population × affluence per capita × energy used per unit of affluence × emissions per unit of energy used.**

The Kaya identity continues to be used to project future greenhouse-gas emissions in most climate projections such as those of the Intergovernmental Panel on Climate Change. Although the two equivalent formulations have advanced the generational thinking, they have their own limits. For instance, both assume unit elasticity i.e. percentage change in one of the right-hand-side variables produces an equal change in stress on the environment. In other words, both in Kaya and IPAT, a 10 percent increase in affluence will increase estimated stress by 10 percent. In view of this, they cannot be used to test hypotheses on the relative contribution of driving forces as the elasticities are assumed to be equal.

Empirical analyses have found such a proportionality assumption questionable i.e. most studies have found that the effects of increased population are more than proportional and hence IPAT and Kaya identities, used with unit elasticities, underestimates the effects of population size. And because they do not take explicit account of culture and institutions, they cannot be used to examine the potential influence of these drivers. IPAT and Kaya have, therefore, been found useful as good starting points but further progress requires a new generation of models that estimates, rather than assume, the effects of each driver net of the others.

3.4.3 A Methodological Critique on Population Focused Studies

Three methodologies were employed in the Population Commission report (of US) and subsequent studies of population, affluence and the environment. The most common is a simulation/projection (S/P) approach. Resource demand or pollution generation is estimated as a function of per capita income. Projections of population and income are then used to estimate future resource demand or pollution. In the more sophisticated models, input-output analysis is used to account for inter-sectoral demand for goods and services. These demands are also translated into impacts on resources and pollution generation.

The final estimated outputs from each sector of the economy are multiplied by coefficients representing the impact per unit output at the most recent point in time for which data are available. In some models, these coefficients can be adjusted to take account of environmental policies or increased efficiency resulting from technological improvement. The S/P model is used to project environmental impacts under various scenarios of population and economic growth. These projections then provide the basis for determining the effects of population and economic growth. The basic logic of the S/P models is to first establish a linkage between total economic activity (per capita activity multiplied by population) and environmental impact. Then alternative scenarios of population and economic growth are projected to assess environmental impacts.

In some models, like the Limits to Growth studies, the structure is a set of linked differential equations and multipliers. In others, the linkages become much more complex. Also, they disaggregate economic activity by sectoral output. But all S/P models make assumptions about environmental impacts on per unit output and then extrapolate into the future under different scenarios of growth. Thus, they do not provide a historical or comparative assessment of the contribution of various driving forces but rather a projection of what may happen, given the assumptions of the model.

The conclusions drawn vary across the several S/P models. Some studies [e.g. the Population Commission results (of US)] suggest only moderate impact of population growth on the environment. The 'Limits to Growth' models and their successors see far greater population impact. Bongaarts (1992) partitions CO_2 emissions into components

for population, affluence, energy intensity due to affluence and the carbon intensity of energy to find that in the less developed nations, affluence changes will dominate the growth in emissions with population growth as the second most important factor. In the more developed countries, growing affluence also drives emissions but changes in energy intensity are more important than changes in population.

The second common approach is that of accounting analysis (A/A) in which the form of the **IPAT** model used is: **I = P*A*T** where **I** is environmental impact, **P** is population, **A** is per capita economic activity (referred to as affluence) and **T** is the impact per unit of economic activity (referred to as technology). Data are obtained on impact, population and affluence and the equation is solved for **T** as: **T = I/(P*A).** This approach has also been applied to the CO_2 efficiency and energy efficiency of economies. When the model is used to assess the relative impact of population and affluence as driving forces, data for two points in time are usually translated into percentage increases for each term in the model. Change in **I** is then allocated to percentage changes in **P**, **A** and **T**.

3.4.4 Commoner's Illustration of IPAT Analysis to Agriculture

Commoner (1992) calculated that the use of synthetic organic pesticides in the U.S., from 1950 to 1967, increased by 266 percent (a ratio of 3.66). During the same period, population grew 30 percent (a ratio of 1.30), crop production per capita by 5 percent (a ratio of 1.05) and pesticide consumption per unit crop production – the technology factor for Commoner – by 168% (a ratio of 2.68). That is:

3.66 = (1.30)*(1.05)*(2.68).

Commoner attributes most increase in the use of synthetic pesticides to technological change, with increased consumption per capita and increased population, each responsible for a smaller share in the increased value of **I** – here the use of synthetic pesticides.

The key problem with this approach is that the relationship is definitive. Once three of the variables are fixed, the fourth is also fixed. In view of this, Ehrlich & Holdren (1972) suggest that Commoner's calculations underestimate the effect of population on the environment by attributing to the **T** term changes that could more properly be allocated to **P** or **A**. Thus, the accounting model is useful for developing efficiency or intensity measures but does not provide an adequate basis for testing hypotheses about the human driving forces of environmental change.

An alternative approach uses historical or cross sectional data on **I**, **P**, **A** and **T** to assess impacts. In its simplest application, this approach uses simple graphs of bi-variate relationships between I and driving forces (or of historical trends in I and driving forces). In more sophisticated methods, the stochastic modelling (S/M) approach has been used most often in studies of deforestation. Despite using slightly different specifications and data sets, all these studies find that population size, growth rate or density has a stronger effect on deforestation than does the economic activity. Rudel (1989) also finds population growth to have a stronger effect than a common measure of trade dependency. These preliminary applications and their findings suggest that the stochastic approach to assessing the impacts of population, affluence, technology and other factors on the environment is a useful way to ground the debate about driving forces in stronger theory and empirical evidence.

3.4.5 Reformulating IPAT: Major Considerations

Anthropogenic global change is being viewed as a real and challenging problem needing systematic investigation. The IPAT model, first proposed two decades ago, represented the efforts of population biologists, ecologists and environmental scientists to formalise the relationship between population, human welfare and environmental impacts. There have since been some new developments to revisit the IPAT model particularly in the context of global environmental changes. These are as follows.

First, the model does not provide an adequate framework for disentangling the various driving forces of anthropogenic environmental change. As a consequence, the IPAT model stifles efforts toward cumulative theory and empirical findings. Second, the argument that population growth would have a strong adverse effect on human welfare has since been revisited. On this, four distinct positions on the effects of population and economic growth on environment are indicated. One view is that the anticipated population growth will have very severe, even catastrophic, impacts on the natural environment and human welfare. A second view acknowledges that while the population growth and economic growth create increased demand for resources, the anticipated scarcity would drive technological progress and with it the search for substitutes and increased efficiency. Thus, the net effect of population and economic growth on resource scarcity, human welfare and the state of the environment is either neutral or even positive. A third position suggests that technologies used to stimulate growth are often selected without regard to their environmental impact. Thus, adverse environmental impacts are more a function of the political economy of technological choice than of population or economic growth per se. To the extent population has an effect on environment, it is an indirect effect that could be mollified by institutional or technological change. The fourth position is a middle ground in which population is not seen as the dominant driving force, but as a contributor to environmental impact acting in consort with affluence, technological choice, institutional arrangements and other factors. While these are the dominant views, there has been little empirical work on the impact of population on the environment. The most extensive literature (found in a series of papers prepared for the U.S. Commission on Population Growth) offers a general conclusion that population growth contributes to environmental degradation but its impact is generally less than the impact of economic growth.

Despite the paucity of strong evidence regarding the effects of population and economic growth on the environment, strong conclusions about the relative importance of the driving forces have continued to appear in the literature. In order to move the debate to more solid ground, it is necessary to reformulate the **IPAT** model in the following six directions.

First it must be considered a stochastic model rather than an accounting scheme so that it can be used to test hypotheses. ***Second***, it would be helpful to employ a variety of indicators of environmental impact and consider the possibility of creating general indices from individual indicators. ***Third***, modelling should incorporate effects of the rate or pace of growth of population distribution and of the composition of the population in addition to the effects of population size as these may have greater environmental impacts than size per se. ***Fourth***, alternatives to gross national and gross domestic product including distributional measures should be considered as measures of affluence. ***Fifth***, technology needs to be assessed directly rather than as the residual of the accounting format. One approach is to incorporate operational measures of technology, such as the efficiency of energy conversion. Another could be to reconceptualise technology to include a variety of driving factors that influence how human activity

effects the environment, including culture, social structure and institutional arrangements. ***Sixth***, because the various driving forces interact in complex ways, it will ultimately be necessary to move from a single equation model – one that estimates only direct effects net of other variables in the model – to a systems model that estimates both direct and indirect effects of driving forces. That is, the model must acknowledge that the driving forces influence each other.

3.4.6 Towards Further Work

With all these modifications, it may seem that the **IPAT** model is losing out in its importance altogether. Indeed, the elaboration of theory about the forces driving anthropogenic environmental change may eventually lead to models that have little relationship to **IPAT**. But **IPAT** is a useful starting point for theory building and testing for three reasons. *First*, any viable theory of anthropogenic environmental change must consider population, affluence and technology as determinants of environmental change. There are other potentially important driving forces that may have strong direct or indirect effects. But **P**, **A** and **T**, almost everyone would agree, must be part of any serious effort to understand human impacts on the environment. *Second*, the **IPAT** model is at the heart of the debates regarding the driving forces. Research that elaborates on it is more likely to influence those debates than research that rejects it. *Third*, the **IPAT** model offers a general framework that can structure both research and discussion, thus providing a means for integrating disparate literatures.

The recognition that humans are causing untoward impacts on the bio-physical environment, a perception once confined to the industrial nations, has now spread across the entire globe. One cannot deny the importance of deepening our understanding of the anthropogenic linkages and causes of environmental impacts. While there is a singular vision of a common destination, there continues to be considerable debate about the best route to get there. Part of the debate stems from the 'trained incapacity' of scholars working within a discipline to recognize affinities in other disciplines, and part stems from the fact that a defining feature of different disciplines is a difference in meta-theoretical assumptions. Such tacitly accepted presuppositions about the proper approach to comprehending a problem allow knowledge to advance within a domain of inquiry, but block attempts to integrate and learn from the interface between disciplines. Split-level dialogues between the social and biological sciences on the topic of population growth have been taking place for over a century. This is precisely why an integrative, human ecological approach has not emerged but which is crucially needed.

Check Your Progress 3 [answer questions in about 50 words in the space given]

1) What is the main argument behind the 'affluent hypothesis'? What is the alternative proposed to this view in the OPSV hypothesis?

.....

.....

.....

.....

2) What is the main criticism on the Inglehart's affluent hypothesis?

.....

.....

.....

.....

3) State the common assumption made for both the IPAT and KAYA identities. In what way this assumption limits its application?

.....

.....

.....

.....

4) How are the 'S/P Approach' applied in practice? What is the basic drawback of this approach?

.....

.....

.....

.....

5) State the one basic problem pointed out for the IPAT model. In light of this, what purpose it serves and what it does not?

.....

.....

.....

.....

6) In the varied studies carried out with population as the focus, what four distinct positions are expressed on the effects of population and economic growth on environment?

.....

.....

.....

.....

7) In the proposed alternative directions in which reformulation of IPAT model is suggested as required, what approaches are indicated for dealing with 'technology'?

.....

.....

.....

.....

8) Despite the IPAT's limitations, for what reasons IPAT is still considered useful for advancing knowledge by theory and testing?

.....

.....

.....

.....

3.5 LET US SUM UP

The unit has addressed to delineating the poverty-environment-population linkages. Two simple formal specifications viz. IPAT and KAYA identities are explained. A reformulated **IPAT** model is then indicated to provide a useful compass for setting us on the journey toward a deeper understanding of anthropogenic environmental change than we possess at present. The model is simple, systematic and robust: simple because it incorporates key anthropogenic driving forces; systematic because it specifies the mathematical relationship between the driving forces and their impacts; and robust because it is applicable to a wide variety of environmental impacts. A reformulation of the model to stochastic form would enable the testing of hypotheses with conventional statistical procedures. First approximations for some impacts, such as CO_2 emissions and deforestation, can be obtained immediately with the application of these statistical procedures to available data. However, key challenges for the model remain, such as the choice of the most appropriate indicators for the primary variables. Limitations on the availability of relevant data as well as quality problems on existing data also remain. Towards this, some strategies for meeting these challenges are indicated in the unit. The unit has aimed at generating a keen interest in this direction to help prod on towards a deeper understanding of one of the most challenging intellectual problems of our age viz. the anthropogenic environmental change.

3.6 KEY WORDS

Endogenous Poverty and Exogenous Poverty : Endogenous poverty is poverty caused by environmental degradation while exogenous poverty is poverty caused by factors other than environmental degradation.

IPAT : Is a conceptual expression to suggest what factors create environmental impact (I) in the first place. The factors considered are: population, affluence and technology. The equation indicates the verity of multiple drivers of environmental change whose effects are multiplicative.

KAYA Identity : Is the modified version of IPAT in which the multiplicative drivers are considered as: population, GDP per capita, energy consumption per capita and emissions per unit of energy used. The identity is mainly used to project future green house gas emissions in climate projections.

3.7 SUGGESTED REFERENCES FOR FURTHER READING

1. Bongaarts, John (1992), 'Population Growth and Global Warming', *Population and Development Review*, 18:299-319.

2. Commoner (1992), Making Peace with the Planet, New York, The New Press.

3. Chertow, Marian R (2001), The IPAT Equation and its Variants: Changing Views of Technology and Environmental Impact, *Journal of Industrial Ecology*, Vol. 4, No. 4, pp 13-29.

4. Dunlap, R. E., & York, R. (2008), 'The Globalization of Environmental Concern and the Limits of the Post-materialist Values Explanation: Evidence from four Multinational Surveys', *The Sociological Quarterly*, *49*(3), pp 529-563.

5. Inglehart, R. (1997), Modernization and Post-modernization: Cultural, Economic, and Political Change in 43 Societies, Princeton, NJ: Princeton University Press.

3.8 ANSWERS/HINTS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) See 3.2 and answer.
2) See 3.2.1 and answer.
3) See 3.2.2 and answer.
4) See 3.2.2 and answer.
5) See 3.2.3 and answer.
6) See 3.2.3 and answer.

Check Your Progress 2

1) See 3.3 and answer.
2) See 3.3.1 and answer.
3) See 3.3.1 and answer.
4) See 3.3.1 and answer.
5) See 3.3.2 and answer.

Check Your Progress 3

1) See 3.4.1 and answer.
2) See 3.4.1 and answer.
3) See 3.4.2 and answer.
4) See 3.4.3 and answer.
5) See 3.4.4 and answer.
6) See 3.4.5 and answer.
7) See 3.4.5 and answer.
8) See 3.4.6 and answer.