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Indira Gandhi National Open University
School of Social Sciences

BECE 143
Environmental Economics

BECE 143

ENVIRONMENTAL ECONOMICS

School of Social Sciences
Indira Gandhi National Open University

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COURSE INTRODUCTION

The first block (**Block 1**) is on 'Introduction' to the course. It has two units. **Unit 1** is on 'Economy and Environment'. It begins with an account on the geophysical relation between economy and environment. It then outlines the relationship between 'human actions and ecosystems'. The unit finally explains the interface between 'economic theory and environment'. **Unit 2** is on 'Welfare Economics and Environment'. It begins by making a distinction between 'positive and normative economics'. The concept of 'efficiency' is then explained. The unit then discusses the concepts of 'equity and optimality' and 'environmental policy'.

Block 2 is on 'Theory of Externalities'. The block covers two major areas viz. Market Failure (**Unit 3**) and Coasian Bargaining (**Unit 4**). **Unit 3** first identifies the sources of market failure. It then discusses the properties of 'public goods'. It finally describes the concept of 'externalities'. **Unit 4** is on Coasian Bargaining. It begins by explaining the issue of 'missing markets and property rights'. It then explains how to 'internalise positive externalities' which is the essence of Coasian Bargaining. The limitations of this method of bargaining is also discussed in the unit.

Block 3 is on 'Environmental Policy'. It has three units: Command and Control Policy Approach (**Unit 5**), Market Based Instruments (MBIs) (**Unit 6**) and Implementation of Environmental Policy (**Unit 7**). **Unit 5** discusses the issues of 'rationale for regulations'. The economics of enforcement of the CAC (command and control) approach and the important issues related to the CAC policy are then explained. **Unit 6** discusses the concepts of pollution or Pigouvian tax, tradable emission permits, subsidies and refundable deposits, etc. **Unit 7** discusses the issues in the formulation and implementation of environmental policies.

Block 4 is on 'International Environmental Problems'. It has two units. **Unit 8** is on Transboundary Environmental Problems. It discusses issues of (i) transboundary pollution, (ii) economic analysis of 'global warming and climate change' and (iii) 'international environmental agreements'. **Unit 9** is on Trade and Environment. It covers (i) the issues of economic growth and environmental quality, (ii) explanations for the Pollution Haven Hypothesis and (iii) investment decisions on environmental sustainability at international level.

Block 5 is on 'Valuation of Environment'. It has three units. **Unit 10** is on Economic Value of Environmental Services. It covers the issues of environmental services and its measurement. **Unit 11** is on Non-Market Valuation of Environmental Services. This unit discusses three methods of valuating the non-market environmental services viz. (i) contingent valuation method, (ii) travel cost method and (iii) hedonic price method. **Unit 12** is on Green Accounting. It discusses the issue of 'cost of depletion and damage to natural resources'. In its light, it explains the conventional 'system of national accounts (SNA)' and points out the requisite modifications therein.

The unit also discusses the elements of an environmentally accounted system of accounts viz. the System of Environmental Economic Accounting (SEEA).

Block 6 is on Sustainable Development. This block also has two units. **Unit 13** is on Concept of Sustainability. This unit discusses issues like (i) different perspectives on sustainable development, (ii) the two broad approaches to measuring sustainable development and (iii) the various sustainability rules. It explains the critical issues in measuring sustainability. **Unit 14** is on Growth and Environment. The unit begins with an outline on the income-environment relationship in terms of the 'environment Kuznets curve (EKC)'. This is followed by an account on the different explanations to the EKC. In the context of international trade, the unit discusses the three hypotheses of 'displacement, pollution haven and factor endowment'. The various factors which needs to be efficiently tackled in order to have a 'market mechanism' capable of preventing environmental degradation is finally analysed in the unit.

BLOCK 1
INTRODUCTION

INTRODUCTION TO BLOCK 1

Block 1 is introductory to Environmental Economics. It has **two units**. **Unit 1** is on Economy and Environment. The unit explains the geo-physical relation between economy and environment in terms of two theoretical models viz. material balance model and laws of thermodynamics. The relationship between human actions and ecosystem is then discussed in terms of (i) consumption of environmental services, (ii) resource base for production, (iii) service rendered by environment as the receptor of wastes generated by consumption and production activities and (iii) the cultural and aesthetic value of environment to mankind. Finally, the interface between economic theory and environment is explained in terms of (i) sustainable development and (ii) the Doughnut model.

Unit 2 is on a review of Welfare Economics and Environment. Beginning with a distinction made on the positive and the normative dimensions of economics, the unit discusses efficiency from the dimensions of (i) consumption, (ii) production and (iii) the product-mix. Drawing a distinction between equity and optimality, the unit finally underscores the importance of 'environmental policy'. For this, it employs two theoretical criteria viz. (i) Pareto improvement criterion and (ii) Kaldor-Hicks compensation criterion.

UNIT 1 ECONOMY AND ENVIRONMENT*

Structure

1.0 OBJECTIVES

After reading this unit, you will be able to:

- elucidate the relevance of the materials balance model;
- relate the laws of thermodynamics to the importance of maintaining the environmental balance in terms of resources and residual flows;
- explain the implications of the laws of thermodynamics for the interaction between economy and environment;
- state the different services of Nature to the economy;
- discuss the linkage between natural resources and human well-being;
- outline the interface between economic theory and environment;
- define the concept of sustainable development; and
- indicate the relevance of the Doughnut model.

1.1 INTRODUCTION

An economy is defined as the set of economic agents (typically households, firms, and the government) and the interactions that take place between these agents, often within the framework of market institutions. The term environment,

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on the other hand, has several connotations. In a very general sense, it can refer to the 'natural setting' in which we live and operate. In this sense, we can identify our 'home environment', 'work environment', 'business environment', and so on. However, a more common connotation which we will use in this course is the ecological definition of environment. This concept treats environment as the amalgamation of: (i) ***atmosphere*** (i.e. the envelope of gases surrounding the earth); (ii) ***hydrosphere*** (i.e. all water on the earth's surface such as lakes and seas); (iii) ***lithosphere*** (i.e. the outer part of the earth consisting of the crust and upper mantle); and (iv) ***biosphere*** (i.e. the layer of the earth where life exists) along with the interactions among these components. In other words, the environment includes all life forms, energy and material resources which surround us.

At first glance, the economy and the environment, as defined above, appear to be quite disjoint and separate. However, they have complex inter-linkages between them. The interaction between the two results in changes in the behaviour of economic agents as well as the quality of the natural surroundings. Activities and actions of economic agents can have an impact on the environment and changes in the environment influence the performance of the economy. There is often, a trade-off between the two i.e. economic growth is sometimes associated with environmental degradation, while at other times, improving environmental quality entails costs for the economy. Thus, several links of interdependence exist between the economy and environment which needs a careful analysis.

Given the impact that environment has on economic agents and their behaviour, studies on environmental change have emerged as an important focal area of the economics discipline. The tools of microeconomic theory are increasingly being used to model problems of the environment and ecology, resulting in subfields like: environmental economics, climate change economics, natural resource economics and ecological economics. Further, the field of development economics, concerned with human well-being, has recognised the role of environmental quality and its sustainable access in ensuring distributional justice, poverty reduction, improving the standards of living by securing productive livelihoods for the poor and the vulnerable, etc. This marriage of development economics with environmental concerns has been influencing the design of policies that focus both on economic development and environmental protection. International dialogue on environmental issues (most notably, climate change) is also being framed in the context of development and growth economics. In fact, six of the seventeen United Nation's Sustainable Development Goals (launched in 2016 and targeted to be met globally by 2030) are directly about clean environment viz. clean water, clean energy, sustainable cities, climate action, aquatic life and terrestrial ecosystems.

1.2 GEOPHYSICAL RELATION BETWEEN ECONOMY AND ENVIRONMENT

The brief account given above makes it possible to see that the economy and environment share an intrinsic relationship. The complementarities between the two motivate the study of the geophysical principles and processes (viz.

the Materials Balance Model and the Laws of Thermodynamics), governing the relationship between the economy and environment. These two important frameworks are discussed below.

1.2.1 Materials Balance Model

You are very well familiar with the circular flow model of economic activity (Figure 1.1). It illustrates the linkages and interdependence between the two sectors of households and firms where, for simplicity, we have ignored the government sector. Households demand goods and services from firms and simultaneously supply factors of production (i.e. inputs like land, labour and capital) to them. The interactions take place in the output and factor markets respectively i.e. factor inputs 'flow' from households to firms with factor payments (e.g. income, wages, rent) and goods and services 'flowing' backwards from firms to households generating, in turn, revenues and profits for the firms.

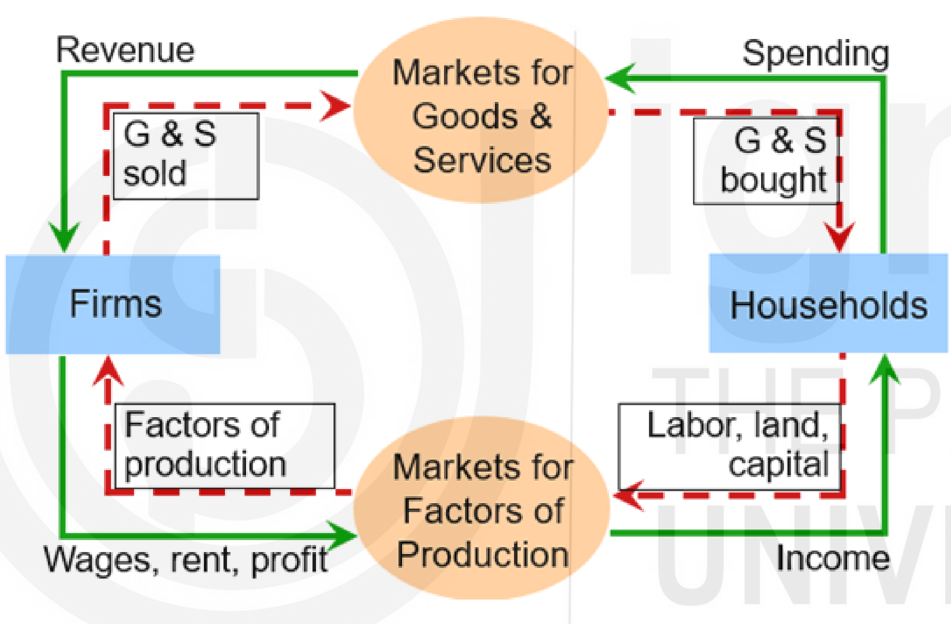

Fig. 1.1: The Circular-Flow Diagram

Source : Mankiw, Principles of Microeconomics (6th edition), page 25.

The circular flow model can be modified to incorporate the environment presenting the extension known as the Materials Balance Model (Figure 1.2). The arrows and square dots represent the interactions in market between the economic agents viz. households and firms. The Materials Balance Model introduces two additional linkages of these economic actors with Nature: ONE to indicate that Nature provides resources to firms (i.e. inputs for production such as water, minerals, sunlight, etc.) and households (e.g. fruits, vegetables, firewood, drinking water, to name just a few) and TWO to indicate that Nature acts as a sink (or receptacle) for the by-products of consumption and production. For instance, smoke (residual of coal-based industries), solid waste (paper or unconsumed food), effluents (emitted by chemical industries), etc. are all let out into the environment (the long dashed arrows *from* households and firms towards Nature represent this interaction in Figure 1.2). Some of the residuals are utilised as input for production or for consumption through recycling (e.g. recycling of plastic waste, paper, etc.). Thus, recovery, recycling and reuse serve as important processes to delay the generation of residuals to be let into the environment. The two links can, therefore, be summarised as: the flow of **resources** *from* the environment to the economy, and the flow of **residuals** *from* the economy to the environment. These links apparently make the two-way interaction between ecology and economy.

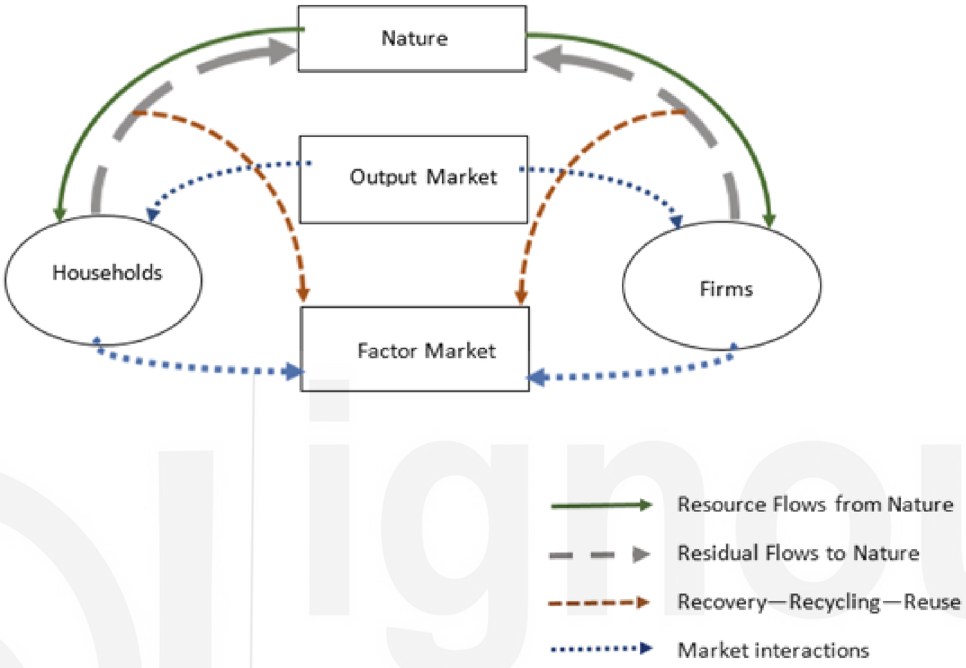

Fig. 1.2: The materials Balance Model

Source: Modified from Kneese, Ayres, and D'Arge (1970).

1.2.2 Laws of Thermodynamics

Just as the interactions between economic agents in the circular flow model are governed by the 'laws of demand and supply' (i.e. 'market forces') and the price mechanism (i.e. 'invisible hand'), the resource and residual flows in the materials balance model are governed by the 'laws of thermodynamics'. Knowledge of the first and the second laws of thermodynamics, in particular, are crucial to understand the mechanics of the materials balance model outlined above.

The first law of thermodynamics states that there is a given amount of energy in the Universe and this total amount does not change. The implication of this law is that the energy can neither be created nor destroyed but can only change its form or get transferred from one object to another. For instance, when we burn coal and wood, the chemical energy stored inside them is released upon combustion in the form of heat and light energy. Further, on burning, the matter trapped inside the wood or coal gets transformed into ash and soot. In relation to the materials balance model this law, therefore, informs us that the energy provided by the natural resources is transformed into other forms of energy required by economic agents. More generally, therefore, all matter provided by Nature gets transformed into some useful products and some unused material. For instance, fruits and vegetables are consumed by humans, while the residuals such as peels and seeds find their way back into the ecosystem.

The second law of thermodynamics discusses 'entropy' (defined as the measure of 'disorder'). It states that all systems tend towards disorder i.e. energy flows from higher concentration (*low* entropy) to lower concentration (*high* entropy) and, in this process, becomes less useful. To elaborate, let us take the example of a diesel engine which converts mechanical energy to electricity. In this conversion process, some energy is leaked out through friction and heat, and ultimately spread out or radiated into space i.e. it is no longer useful. While the first law tells us that energy can never be destroyed, the second law emphasises that although the energy exists, with each conversion or transformation, it becomes less and less useful. Another implication of the second law has to do with ***reversibility***. Earlier, we took the example of wood being burnt to release heat, light, ash and soot. The second law of thermodynamics tells us that this energy and matter transformation is not reversible i.e. we cannot get all the wood back since the burnt up part of wood can never be recovered as wood. Similarly, although paper and plastic can be recycled, there is a limit to how much recycling can be done as with each recycling, some of the quality material will be lost and becomes no more useful. This is the reason why, in the Materials Balance Model, it was shown that only some of the resources can be recovered for production and consumption, while others have to be released into the environment as residuals.

Check Your Progress 1 [answer within the space given in about 50-100 words]

1) What are the four components of environment considered from the ecological perspective? Illustrate the interaction between economy and environment to bring out their interdependence.

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2) In which two respects or links does the Materials Balance Model extends the conventional Circular Flow Model to bring out the interaction between ecology and economy? How does it form a two-way linkage?

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3) Outline the concept of 'entropy' in the context of the second law of thermodynamics. State also one of its other important implications.

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1.3 RELATIONSHIP BETWEEN HUMAN ACTIONS AND ECOSYSTEMS

We are now in a position to understand the several relationships that exist between the environment and humans. In economics, Nature is considered as an asset i.e. natural capital is a part of the total capital stock, providing myriad benefits and services to the humankind. These ecosystem services have already been briefly illustrated in Figure 1.2, where the two main resource flows (to and from Nature, respectively) were identified. Based on these resource flows, we can now identify two primary services provided by the natural ecosystem to humans. The first set of services are ***provisioning*** services i.e. Nature provides several products for direct consumption or production. The second set of services are ***regulating*** services (i.e. benefits that people obtain from the regulation of ecosystem processes such as maintenance of air quality, climate control, erosion control, etc.). The function of the environment as a receptacle for wastes (as shown in Figure 1.2) is an example of a regulatory service.

Apart from the two services mentioned above, humans derive some additional benefits from the ecosystem called ***cultural, amenity* or *recreational*** services. Not surprisingly, each component of the environment often provides a combination of provisioning, regulating and recreational services with an essential overlap among each one of these services. The present section deals with an evaluation of the services provided by the environment and how humans benefit from them in multiple ways. The services provided by ecosystems are illustrated in Figure 1.3.

1.3.1 Directly Consumed Environmental Services

Humans are dependent on the environment to meet their basic needs of sustenance, shelter and energy. The availability of sufficient food with adequate nutrition and safe water are among the basic necessities of human life. In economics, the concept of *poverty* is often defined in terms of calorie consumption i.e. a person is considered *poor* if s/he is unable to afford for consumption a minimum number of calories derived from food on a daily basis. Clearly, this most basic necessity of consumption is directly met by the environment. For instance, cereals (wheat, rice, *bajra*), pulses (lentils), fruits (mangoes, bananas, pears, oranges, etc.), vegetables (carrots, potatoes, onions, cabbage, spinach, etc), nuts (almonds, walnuts, etc.) and herbs (coriander, mint, basil, ginger and turmeric among the most commonly used) are directly sourced from crops, plants and trees. Further, other edible products such as milk, meat and fish, derived from animal sources, form a mix of the overall consumables to constitute an important part of a balanced human diet. Clearly, this is an indispensable necessity for a healthy and productive life.

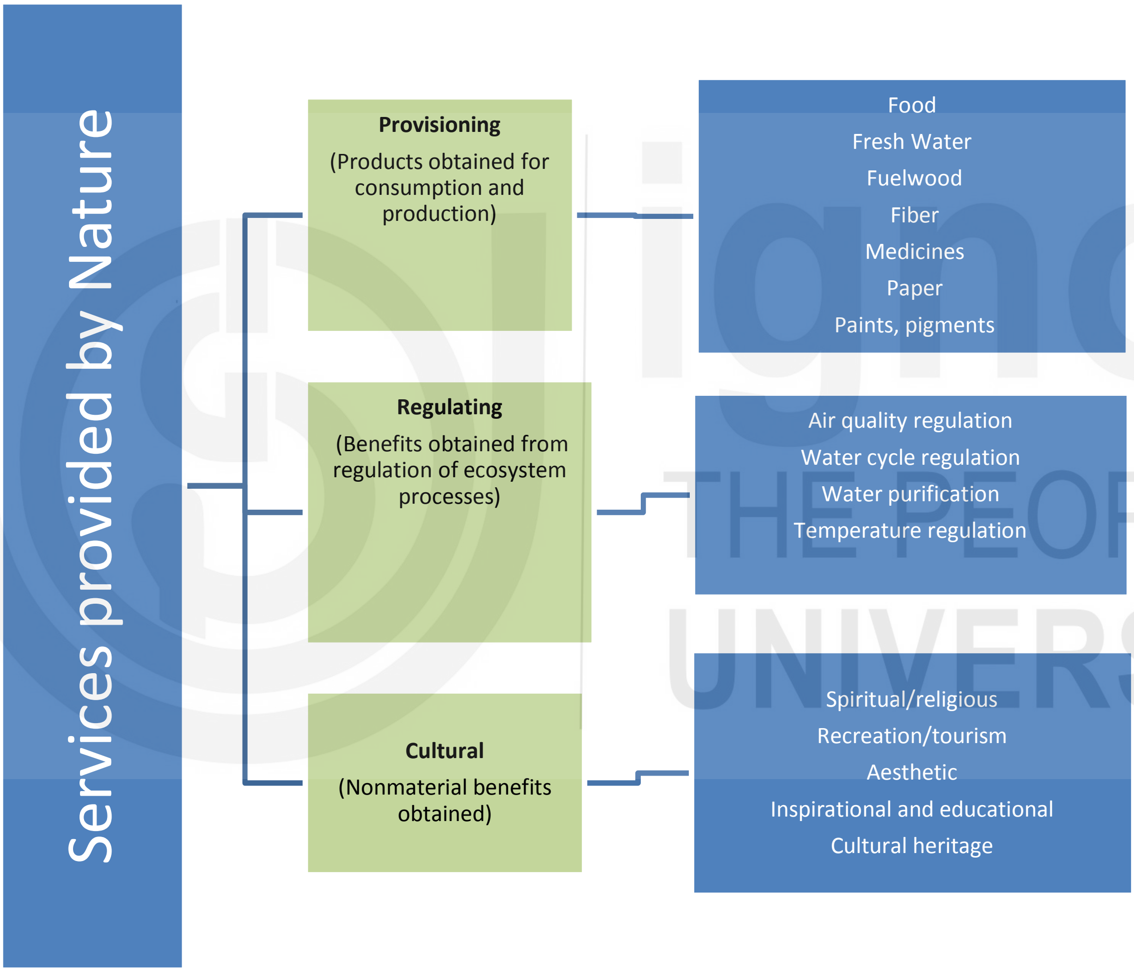


Fig. 1.3 : Services Provided by Nature

Source: Ecosystems and Human Well-Being, A Framework for Assessment (2003).

Apart from these, water is an essential commodity without which life itself cannot be imagined. Historically, many civilisations have come up around rivers, such as the Indus, Nile and others. Freshwater, sourced from rivers fed by glaciers, forms the basis of human existence. Humans, therefore, rely greatly on the environment for the basic materials of life viz. food and water. Other than the fundamental necessities of food and water, Nature also provides us with materials for construction of houses and other buildings.

The environment thus helps to meet our need for shelter as well. Timber (wood), stones, rocks, clay and natural fibres, used to build roofs, walls, 'chulhas' (traditional cooking stovetop) are examples in this regard.

Several of our energy requirements are also met through Nature's endowments. Timber, coal and charcoal are used commonly for heating and cooking purposes, especially by those without access to electricity or other forms of energy. In addition to these, the ultimate source of energy that sustains all life on Earth is sunlight, which reaches us through the atmosphere.

Finally, humans use products from Nature for art and craft: musical instruments made from wood, bamboo and cane artefacts, sand art, pottery, shell jewellery are all sourced from the environment. In India especially, several regional traditional craft forms use nature-derived products such as rice, tree twigs, wood, metal, clay and flower-based natural dyes. To summarise, therefore, dependence of humans on Nature can be found in various aspects of life, whether it be food, water, shelter or recreation. A variety of goods for direct consumption of humans, provided by the environment and ecosystem around us, are presented in Table 1.1 below.

Table 1.1: Direct Consumption Needs of Humans met by the Environment

Consumption Need	Provisioning by Natural Resource
Food and Nutrition	Fruits, vegetables, nuts, oilseeds, herbs, pulses, milk, fish, seafood.
Water	Rivers, lakes ponds
Shelter	Wood, rocks, clay, sand, stones
Fuel	Wood, coal, charcoal
Others (art and craft, clothing)	Wood, clay, flowers, shells

The above discussion highlight the products derived by humans from Nature. However, the links between Nature and economy are not unidirectional. The availability and provisioning of food, fuel and water is greatly affected by human activity. In other words, whether the provision of the above listed products by Nature continues in sufficient quantities depends on the features and volume of human activity. Specifically, population growth and urbanisation patterns place enormous pressure on food, water and land availability worldwide. Investments in infrastructure and technology, can enhance productivity and utilisation of resources by minimising wastage, and also help develop alternative sources of energy, building material, etc. Since there are limits to consumption of natural resources, beyond which their continued usage amounts to exploitation, thereby affecting the natural global environmental system, the two way interaction between economic activity and Nature needs to be harmonised in a sustainable manner.

1.3.2 Resource Asset in Production

In addition to products for direct consumption, the environment also provides key inputs for production of other commodities. Several nature-sourced resources are required in crucial industries such as iron, steel, food processing, manufacturing, paper, construction and others. By enabling and supporting important industrial processes, the environment plays a crucial role in contributing towards macroeconomic growth. Through this channel, the ecosystem also provides employment supporting the livelihoods of those engaged in the industries using natural inputs.

To understand the above more clearly, let us start with the basic resource, water. Apart from direct consumption, water is a crucial input in a wide range of industries such as agriculture and agro-based food processing, paper, textiles, thermal power generation, etc. Further, the tourism industry flourishes around water bodies (e.g. backwaters of Kerala, beaches of coastal areas and lakes, etc.). Apart from water, plants and crops provide inputs for all agro-based food processing industries. These include sugar, edible oils, snacks, packed juices, pickles, energy drinks, etc. Animal and animal products form the backbone of dairy, meat, fishing and honey industries. We also have timber (wood) which is used in manufacturing and construction industries. In addition, forests provide raw material for paper and pulp industries. Natural fibres such as cotton, jute and flax are also provided by forests, while wool and silk are derived from sheep and silkworms, respectively. Various plant and animal extracts are used in the pharmaceutical industries to make medicines, personal care items and cosmetics. Insects and worms have been researched upon to discover their use in developing products such as pest repellents, industrial adhesives and fire detection devices. Microorganisms such as bacteria and fungi have been used in the textile and paper and pulp industries and even in the nanotechnology sector. Broadly speaking, therefore, industries ranging from aeronautics to mining have all seen breakthrough developments due to research in biodiversity. Farming, forestry, grazing and fisheries are other established biodiversity-based industries while the future resource potential of diversity is being actively explored. In other words, the sheer variety of species on Earth provides an avenue for development and discovery of new products and processes.

In sum, biodiversity – defined as the number, abundance and composition of genotypes, populations, species and landscape units – offers the most important ***provisioning service*** to humans by acting as a 'Resource Asset in Production'. Some novel products that have been developed from biodiversity research are summarised in Table 1.2 below.

Table 1.2: Animal and Plant Sources for Commercial Products

Product	Animal/Plant Species Used
Antibiotics	Bacteria, plants, ants
Architectural Design Products	Termites

Fire Detection Services	Fire beetles
Pest Repellents	Insects
High Tensile Fibres	Spiders, moths
Surgical Drugs	Scorpions, wasps
Clinical Drugs	Leeches, fungi
Fibre-Optics	Sponges
Ceramics and Crystals	Snails
Industrial Adhesives (Glue)	Velvet worms
Robotic and Aeronautic Design	Fish, bees, dragonflies, millipedes, worms
Industrial Pigments	Single-cell algae

Source: Millennium Ecosystem Assessment, 2003.

1.3.3 Environment as a Receptacle for Wastes and Provider of Regulating Services

If we refer back to Figure 1.2 above, we see that one of the residual (or unused) resource flows goes from households and firms to Nature. These are the substances released during economic activity– the by-products or residuals of production and consumption activities. Some of these substances are harmful for humans and other life forms (e.g. smoke and toxic waste, especially in large amounts). Several ecosystem processes reduce the concentration of such contaminants, thereby regulating the living environment around us. In other words, the Nature detoxifies or eliminates excess toxins discharged by humans, thus acting as a receptacle of wastes or a 'waste sink'.

Economic activities, ranging from industrial production to agriculture to transportation, create residuals. The second law of thermodynamics tells us that these residuals are simply matter or energy less useful than the original source of energy. Combustion of fossil fuels (coal, oil, etc.) release carbon dioxide and heat into the atmosphere, incineration (or burning) of solid waste releases particulate matter, mining activities result in acidification of water contaminating surrounding water and soil, etc. Similarly, agricultural activities such as the use of pesticides and insecticides discharges chemicals into the air while preparing land for cultivation by burning forests emits particulates and greenhouse gases. In addition, human settlements are another important source of waste. Transportation releases greenhouse gas emissions and lead, while heating and cooking releases particulates. Human habitation is also the source of solid and semi-solid waste such as trash (including but not limited to plastic, glass and paper), sewage (organic matter and biochemical residue) and other hazardous materials (paints, cleaning substances, batteries, etc.). In sum, production processes and day-to-day human activities introduce different types of wastes into the environment.

Excess concentration of the substances mentioned above is harmful for humans and other living organisms. In addition, accumulation of such wastes imposes economic losses as well. Such losses include impairment of human health, loss of biodiversity and economic losses due to injury to ecosystem or organisms. For instance, pathogens in sewage wastes are the carriers of many communicable diseases and infections claiming the lives of several children every year, especially in developing countries. Further, exposure to heavy metals such as mercury, lead and other toxic chemicals in large concentrations is known to be associated with cognitive (learning) disorders, skin diseases and growth impairment. Perhaps, one of the most visible environmental contaminants is air pollution which aggravates asthma and other respiratory diseases, skin irritations, eye irritations, etc. An unhealthy environment, in general, leads to loss of productivity for humans, resulting in economic costs. In addition to direct adverse impact on human health, harmful wastes destroy the habitat of organisms (causing not only loss of biodiversity but also economic damage) thereby becoming a detriment to the livelihoods of those dependent on such ecosystems/organisms. For instance, over-accumulation of sewage waste in water bodies reduces their oxygen content, making them inhospitable for the fish population, thereby directly harming the fisheries industry. The steady deterioration of coral reefs in Australia has affected the tourism industry. Finally, toxins such as acid rain (caused by excess sulphur dioxide) lead to loss of infrastructure and property due to its corrosive nature. A brief summary of these damages and their sources are listed in Table 1.3. Given the serious nature of damages associated with the excess wastes generated by humans, the importance of the crucial service of absorbing these undesirable by-products carried out by the environment needs to be recognised.

Table 1.3: Sources and Damages from Wastes Generated by Humans

Waste	Source	Damage
Carbon dioxide, methane gases	Burning of fossil fuels, deforestation	Global warming, ocean acidification
Carbon monoxide	Burning of fossil fuel	Cardiovascular diseases, neurological problems
Sulphur dioxide	Burning of fossil fuel	Respiratory diseases, acid rain
Sewage waste	Human excrement	Carrier of disease causing pathogens
Toxic metals (mercury, lead)	Mining and other production processes	Genetic disorders
Pesticides	Agricultural activity	Death of aquatic life
Oil spills	Shipping accidents	Death of aquatic and bird life

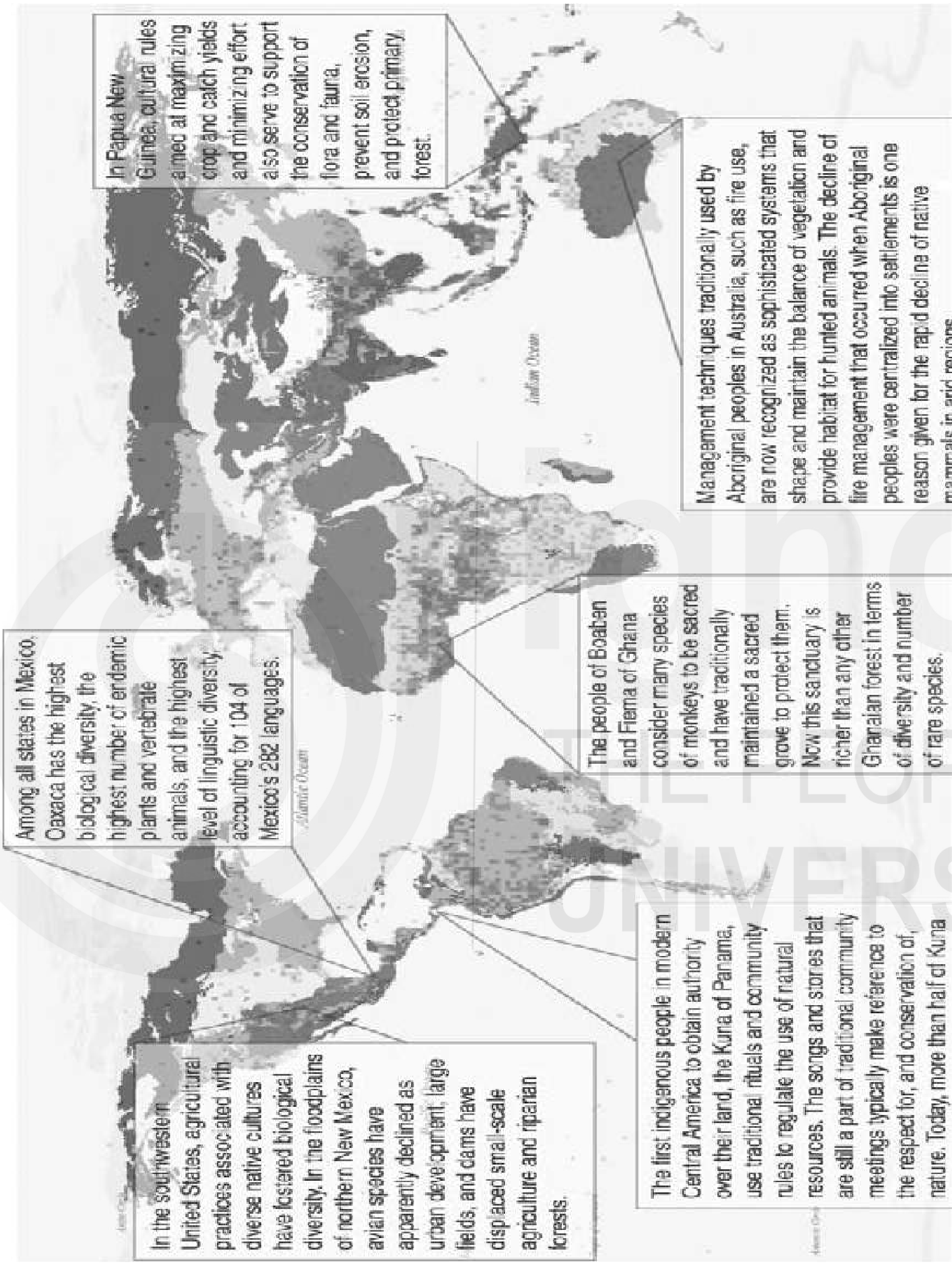
Source: Millennium Ecosystem Assessment, 2003.

Macroeconomic trends indicate that economic activity and human population has increased manifold worldwide over the centuries. This increase has been associated with an exponential rise in the amount of residue and waste matter as well. Implicitly, economic agents have assumed that the environment has an infinite 'carrying capacity' and can continue to absorb vast amounts of waste. However, this is not true. There exist limits to the speed and capacity of the ecosystem to detoxify itself. This lack of synchronization between the speed and volume of waste generation and the pace and capacity of detoxification by Nature has manifested in the form of increasing levels of pollution and toxins, ultimately hampering the well-being of humans, especially the vulnerable groups. The rapid pace of growth of human activity is affecting the environment's ability to remove the toxins from the ecosystem. Environmental policy has an important role to play in slowing down the pace of waste generation so as to allow its timely and adequate assimilation by Nature.

Atmospheric cleansing and cooling, air purification, flood and fire regulation, carbon sequestration and chemical balancing are some of the other processes through which Nature's capacity for absorption of toxic materials can be aided partly compensating for increased anthropogenic (human-caused) activities contributing to unsustainable levels of bad emissions into the environment. Likewise, upcycling, recycling and reusing are some of the methods which humans to reduce the pace of toxic releases into the environment. Without these mitigating steps by humans the receptacle service by nature would suffer. Consequently, humans would face an increased frequency of natural calamities, health hazards and economic losses.

1.3.4 Cultural and Aesthetic Services

In addition to provisioning and regulating services, Nature is also a source of providing intangible benefits through its cultural, amenity, recreational and aesthetic services. Flowers and plants are of decorative/ornamental value, while nature trails, waterfalls and mountains are components of aesthetically pleasing sceneries which support local tourism. Further, Nature is intrinsically tied to the cultural, religious and spiritual identity and social values of communities (Figure 1.4), apart from being a source of indigenous knowledge (such as Ayurveda and Unani, traditional systems of medicine in the Indian subcontinent). Ecosystems and landscapes remind us of our historic roots, and all around the world, human cultures have been influenced by the surrounding ecology. Traditional wisdom considers humans and Nature to be part of an 'indivisible whole' who should live in partnership with each other. Thus, ecosystems form an important part of the cultural and natural heritage. In India, especially, we observe several traditions and practices related to plant species considered sacred (e.g. peepal tree, tulsi plant). Similar traditions can also be found in Chinese, Japanese and Mayan cultures (Figure 1.4).



Source: Millennium Ecosystem Assessment, Chapter 17

Fig. 1.4: Links between Language, Culture, and the Natural Environment

In general, six categories of the links between human cultures and ecosystems can be identified. These are: (i) cultural identity; (ii) spiritual services; (iii) heritage value; (iv) inspiration for art and craft; (v) aesthetic appreciation; and (vi) recreation and tourism. Human activity affects the nature's ability to provide some of these services. Thus, we can summarise by saying that economic processes, by affecting ecosystem's processes, ultimately impact upon human well-being, in a positive or negative manner. The aspects of human well-being affected by Nature are presented in Table 1.4 below.

Table 1.4: Constituents of Human Well-Being

Security:	Basic Material for Good Life	Health	Good Social Relations
• Shelter • Safe surroundings	• Food • Water • Livelihoods	• Nutrition	• Aesthetic and recreational benefits

Source: Millennium Ecosystem Assessment, 2003.

Check Your Progress 2 [answer within the space given in about 50-100 words]

1) Distinguish between the ***provisioning*** and ***regulating*** services provided by Nature with an example of each.

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2) Give some examples in support of the fact 'the most basic necessity of life is met by the environment'.

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3) How are our energy requirements met by the environment?

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4) Is the link between Nature and Economy uni-directional? If not, what needs to be done to maintain the required balance in this regard?

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5) Give some examples to establish that environment contributes to macroeconomic growth.

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6) How is bio-diversity defined? Give some examples to establish that bio-diversity offers important services by acting as a 'Resource Asset in Production'.

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7) Environment having limited 'carrying capacity', what measures could help in slowing down the pace of toxic releases into the environment?

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8) What are the categories of links into which human cultures and ecosystems are grouped? Give examples of constituents of human well-being which are affected by the exploitative use of environmental resources.

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1.4 INTERFACES BETWEEN ECONOMIC THEORY AND ENVIRONMENT

Sir Partha Dasgupta, renowned economist, once noted that the analysis of the 'natural world' in the economics profession has remained isolated from the main body of contemporary economic thinking. For example, the first model taught to a budding macroeconomist, the circular flow model, conveniently ignores the dependence of the economy on the environment (as discussed in Section 1.2 above). While some concepts of microeconomic theory, such as externalities and public goods are used to analyse the problems of pollution and overuse of natural resources (tragedy of the commons), environmental concerns have largely remained missing from the larger macroeconomic narrative focused on growth and aggregate income. Only recently, one of the most serious environmental concerns, namely global warming, has become part of the discipline's mainstream discourse [thanks to Lord Nicholas Stern's Review of the Economics of Climate Change (2006)]. The costs of global warming and policy options for its mitigation have generated widespread debate and discussion. More generally, the applied areas of environmental economics and natural resource economics have started to gain prominence in policy circles and are not considered peripheral anymore. Some of the new economic paradigms incorporating environmental concerns are briefly discussed in this section.

1.4.1 Sustainable Development

Sustainable development, a broader concept than economic growth, focuses on the twin goals of poverty reduction and conservation of the natural endowments so as to protect livelihoods without hampering the environment further. The concept of sustainable development, introduced in the Brundtland Commission's report (1987), is a pursuit of the path of economic progress which does not impair the welfare of future generations. In other words, sustainable development emphasises the exploration of win-win opportunities that allow for coexistence of growth/development and environmental protection (i.e. development that can be 'sustained' into the future). The precise definition expresses this notion as 'meeting the needs of the current generation without compromising the needs of the future generations'– the needs being economic, social and cultural. To ensure this intergenerational equity, it has been ideated that the current generations are obliged to leave a bequest of natural capital to the future generations so that each generation inherits a natural environment of a type similar to which the earlier generation had enjoyed. Given the dependence of humans on the environment, it should seem logical that bequeathing a sufficient amount of natural resources could enable future generations in meeting their multiple needs.

There exist complex issues in understanding the notion of sustainable development. Foremost is the course of measuring natural capital which is made up of diverse components such as forests, oceans, biodiversity, etc. In the absence of well-developed markets for these resources, it is difficult to arrive at an aggregate 'monetary value' of natural wealth. In such a scenario, how do we ensure that we pass on a stock of natural capital to the future generations, at least the same as the one we inherited? Ample research is ongoing in developing rigorous techniques of valuation, measurement and aggregation of natural resources to meet this knowledge gap.

1.4.2 Doughnut Model

Kate Raworth of Oxford University has recently developed the 'doughnut model', which illustrates the social and planetary boundaries the global economy must operate within. It is an extension of the concept of nine planetary boundaries proposed by Rockström [et al. (2009)]. In Rockstrom's model, the nine boundaries form a circle and the area in the middle is labelled as the 'safe operating space for humanity' (Figure 1.5). Some of the boundaries have already been breached, and we are in the zone of 'high risk' with respect to ***biogeochemical flows*** and ***genetic diversity***, as shown by the shaded area in the diagram. In the matters of climate change and land system change as well, we are fast approaching the high risk area. Raworth refines this diagram further by adding *social* boundaries to it (Figure 1.6). The modified diagram depicts two frontiers:

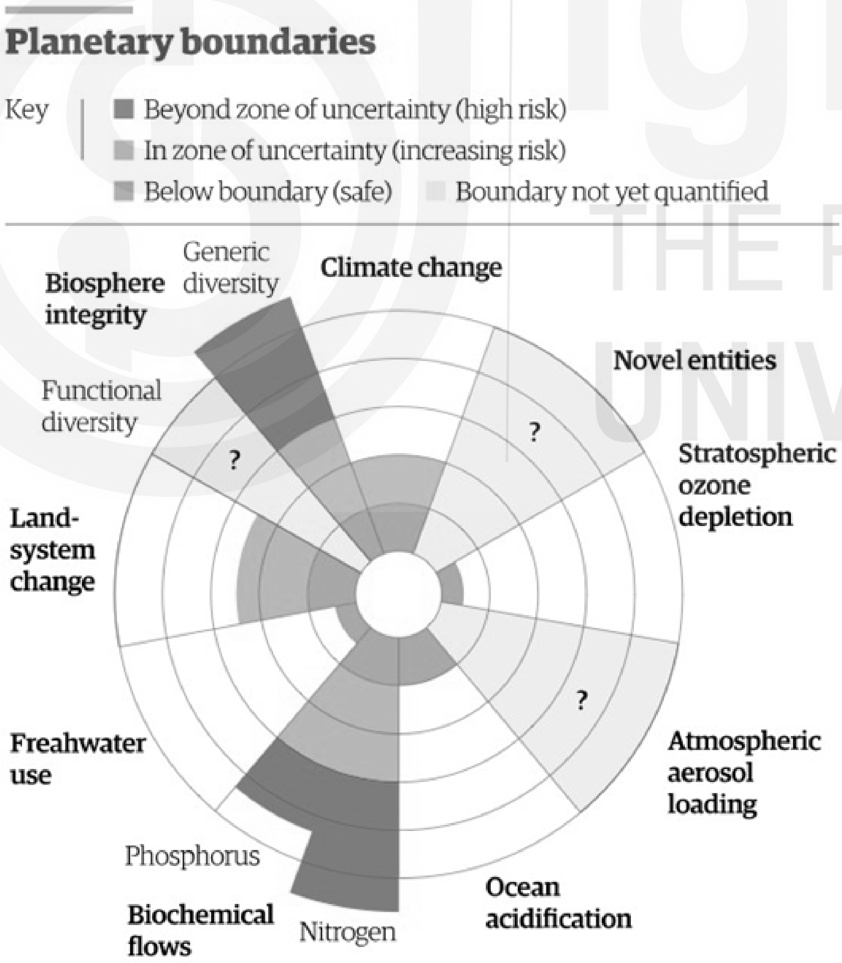

Fig. 1.5: The Nine Planetary Boundaries

Source: Rockström et al. (2009).

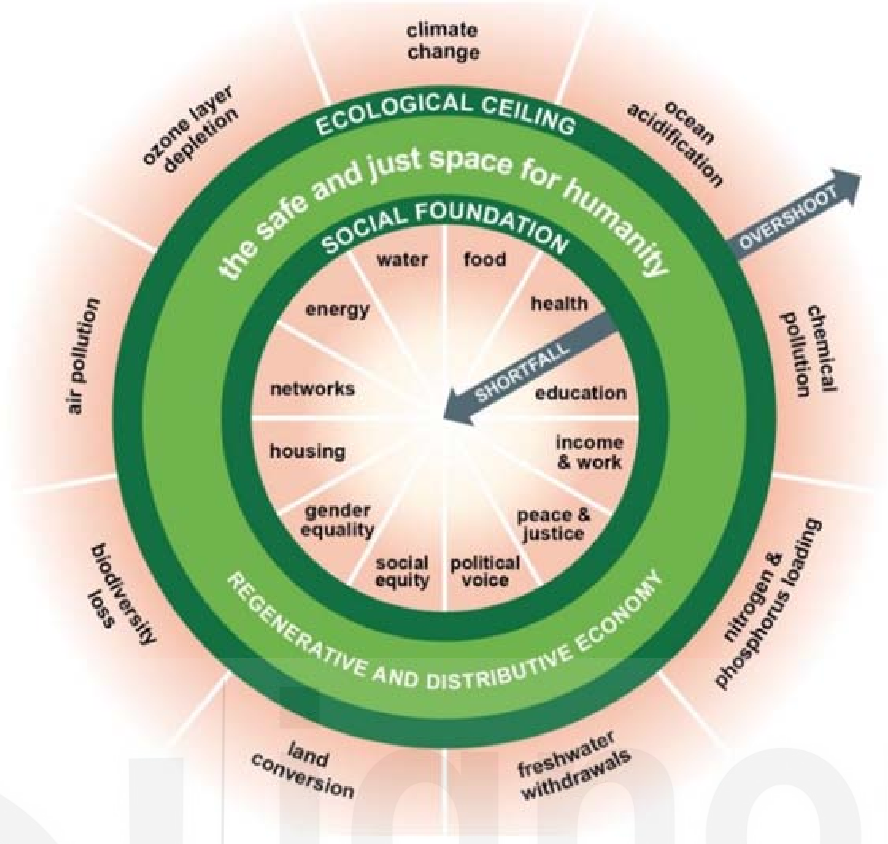

Fig. 1.6: The Doughnut of Social and Planetary Boundaries

Source: https://www.kateraworth.com/doughnut/

one, the ***environmental ceiling of resource use***, above which lies unacceptable environmental degradation, and, two, the ***social foundation of resource use***, below which lies undesirable human deprivation. The representation thus integrates issues of poverty, inequality and welfare in the framework. In this model, the area between the two boundaries (the 'doughnut') is the '***safe and just space for humanity***'.

This powerful idea is expected to serve as a replacement to the circular flow model. The diagram highlights the limitations of the planet, with respect to the volume of human activity it can take, and at the same time, indicates the importance of equitable distribution of resources needed to fulfil the human rights and needs of the people. These fundamentals can serve to provide the right kind of focus to policy planners engaged in designing regulatory instruments to enable humanity to thrive in the '***safe and just zone***'.

Check Your Progress 3 [answer within the space given in about 50-100 words]

1) How is 'sustainable development' defined? What are the twin goals on which is it focused?

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2) In what way the doughnut model of economic growth an improvement over the circular flow model?

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1.5 LET US SUM UP

There exist intrinsic two-way links between the economy and the environment. Nature provides several diverse services to the economy which contribute to the enhancement of human well-being while economic activity affects the ability of Nature to provide these services. This relationship is governed by the laws of thermodynamics, and is subject to the limitations of planetary boundaries. Traditional theories of economics are in the process of being modified to incorporate the role of environment in ensuring economic progress.

1.6 KEY WORDS

Sustainable Development : Economic progress that meets the needs of the current generation without compromising the needs of the future generations.

Waste Sink : The service provided by the environment wherein it acts as a receptacle of residuals generated by human activity.

Upcycling and Recycling : Upcycling can take place in perpetuity (i.e. forever) while recycling mainly delays the final disposal of waste material.

1.7 SOME USEFUL BOOKS AND REFERENCES

1) Collier, P (2010). The Plundered Planet: How to Reconcile Prosperity with Nature. London: Allen Lane.

2) ICSU-UNESCO-UNU (2008). Ecosystem Change and Human Well-being: Research and Monitoring Priorities Based on the Millennium Ecosystem Assessment. Paris, International Council for Science.

3) Mankiw, N. (2008). Principles of microeconomics. 5th ed. Mason, Ohio: South Western, p.25.

4) Millennium Ecosystem Assessment (Program) (2005). Ecosystems and human well-being. Washington, D.C: Island Press.

5) Pearce, D. W., Markandya, A., Barbier, E., & Great Britain (1989). Blueprint for a green economy. London: Earthscan.

1.8 ANSWERS/HINTS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) Atmosphere, hydrosphere, lithosphere and biosphere. For interdependence between economy and environment see Section 1.1.

2) One, to indicate that nature provides resources needed for production and, two, to indicate that nature acts as a 'sink' to the by-products generated (Sub-section 1.2.1).

3) Defined as the measure of 'disorder', its important implication relates to the extent of 'reversibility' (Sub-section 1.2.2).

Check Your Progress 2

1) Air, water, etc. are provisions provided by nature. Trees and forests help in maintaining the purity of air, control floods, etc. (Section 1.3).

2) Cereals, pulses, fruits, vegetables, herbs, etc. (Sub-section 1.3.1).

3) Water, wind, coal, etc. are all basic source for generation of energy or power (Sub-section 1.3.1).

4) Volume of human activity is a determining factor for which sustainable practices are needed to be diligently observed (Sub-section 1.3.1).

5) All agro-based industries draw their requirement of raw materials from agriculture. Industrial needs of iron and steel are also available from nature (Sub-section 1.3.2).

6) Defined as 'number, abundance and composition of genotypes', it offers raw material supply to many industries (Sub-section 1.3.2).

7) Atmospheric cleansing and cooling, air purification, flood and fire regulation, carbon sequestration and chemical balancing are some of the measures (Sub-section 1.3.3).

8) Cultural identity, spiritual services, heritage value, inspiration for art and craft, etc. (Sub-section 1.3.4).

Check Your Progress 3

1) Meeting the needs of the current generation without compromising the needs of the future generations. Its twin goals are poverty reduction and conservation of the natural endowments (Sub-section 1.4.1).

2) By adding *social* boundaries (Sub-section 1.4.2).

UNIT 2 WELFARE ECONOMICS AND ENVIRONMENT*

Structure

2.0 OBJECTIVES

After reading this unit, you will be able to:

- distinguish between 'positive economics' and 'normative economics';
- define the concepts of 'efficiency' and 'equity';
- discuss the concepts of efficiency in 'consumption, production and product-mix' ;
- state the general form of 'social welfare function' with three of its major specific forms viz. utilitarian, Rawlsian and egalitarian;
- specify the efficiency conditions under which the social welfare function is optimised; and
- explain the criteria for 'policy evaluation' in terms of 'Pareto Improvement Criterion' and 'Kaldor-Hicks Compensation Criterion'.

2.1 INTRODUCTION

The previous unit presented a non-technical discussion of the links between the environment and economy. The unit also hinted towards the growing

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importance of applying economic analysis to environmental problems. Beginning with the current unit, we will undertake a more formal treatment of the links between the environment and economics. More precisely, we will try to understand the role of economists in designing environmental policy. In other words, we will explore the use of methods of economic analysis (by considering the concepts of welfare and micro economics), to identify and relate them to environmental problems for aiding the design of policies to correct or mitigate the same.

While we define 'welfare' more precisely later in this unit, for now, we shall use the terms welfare and well-being interchangeably. The purpose of all economic policy in general, and environmental policy in particular, is to increase social welfare. A course in environmental economics can thus be considered a course in applied welfare economics. With this background, we shall now turn to the field of welfare economics in this unit. Welfare economics, as defined by Baumol (1977), is the branch of economic theory which investigates the nature of the policy recommendations that the economist would make. Thus, several fundamental results from the field of welfare economics can be drawn upon while evaluating environmental policy decisions.

2.2 POSITIVE AND NORMATIVE ECONOMICS: DISTINCTION

Economics, and therefore economists, have two primary roles. First, economic tools can be used to explain the 'state of the world' or the happenings around us. In other words, economics answers the question of 'what is'? The use of economics to describe the state of world in the 'what is' perspective is known as *positive economics*. A key feature of positive statements is that they can be tested (in principle) using evidence. Alternately, economics can be used to explain 'what should be', or, how we wish the economy to allocate its resources alternatively for increasing the overall welfare. This alternate perspective is called *normative economics*. In other words, 'positive economics' is free of value judgement i.e. it is neutral in its approach. On the other hand, normative economics, attempts to *suggest* how the economy should function. It therefore inevitably involves defining what may be the 'best' way to do so. Hence, it entails making (often unverifiable) value judgements. These statements typically include words such as 'should', and 'must'. Often, normative statements can be rephrased to make them positive statements. For example, 'there should be a tax on pollution' could be rephrased as 'imposing a pollution tax would result in lowering of emissions'. The positive statement thus formed can be tested using economic theory and tools.

As stated above, environmental policy involves identifying the problem and correcting for environmental distortions. While the identification of the problem is in the realm of positive economics (i.e. in describing the problem), devising measures to rectify the problem falls into the territory of normative economics or analysis. The latter is because normative economics tries to answer what *kind* of government intervention would be required to achieve the rectification of the problem. While different economists would typically arrive at the same conclusion regarding what the problem *is,* they may have diverse opinions on what the ideal solution *should* be, thereby offering different recommendations. In other words, positive analysis objectively observes, quantifies and characterises the behaviour of economic agents, while normative analysis identifies what policy should be pursued to achieve better welfare.

In general, an environmental problem can be viewed both from the positive and normative lens. For instance, a positive analysis of the climate change issue would entail measuring the effect of climate change on various sectors (e.g. agriculture and fisheries). More precisely, it could attempt the quantification of the observed losses in agricultural productivity and fishery yield due to climate change and also project under different scenarios value-neutral assessment of the problem. On the other hand, a normative evaluation of the issue would enable policy makers to answer questions such as: 'what action should be taken to mitigate the effects of climate change', 'when should the abatement policies be put into action', and so on. Normative analysis, thus, plays a significant role in spurring policy debates enabling policymakers to decide upon the future course of action. Policymakers (and, indirectly, the people who vote them into power) ultimately decide which policies to implement based on normative judgements. Some (hypothetical) examples of positive and normative claims surrounding environmental policies are presented in Table 2.1 below.

Table 2.1: Positive and Normative Statements

Concern	Positive	Normative
Human role in climate change	Human actions are largely responsible for climate change.	Humans should undertake mitigating actions to reduce the effects of climate change.
Cost of mitigating climate change	Abatement costs total nearly one percent of the forecasted global GDP in 2030.	The cost of mitigating climate change should be borne by developed nations.
Fertilizer subsidies	Subsidies for fertilizer use have resulted in poor soil quality over the years.	Fertilizer subsidies should be removed, and farmers should be encouraged to use natural manure.
Odd-even policy	The odd-even (road space rationing) policy has reduced pollution in Delhi.	The government is correct in introducing the odd-even policy on a permanent basis.
Petrol prices	If petrol prices increase, people will use more public transport.	Increasing petrol prices through a tax is a good idea.

2.3 EFFICIENCY

An allocation of resources is efficient if it is not possible to make anyone better off, without hurting at least one person in the economy. In simpler terms, an efficient allocation is a 'no-waste' allocation i.e. all resources have been fully employed such that any reallocation will necessarily involve the worsening of the position of at least one economic agent. Economic efficiency is characterised by efficiency in consumption, efficiency in production, and product-mix efficiency. These three conditions are discussed in this section of the unit for a two agent case for the reason that it permits a graphical analysis as is usually done to begin with in microeconomics. Its extension to multiple agent case could be made using methods like vector analysis which we shall keep outside the purview of the current unit.

2.3.1 Efficiency in Consumption

Given two individuals A and B, and their utility functions (assumed to be quasi-concave and differentiable), an allocation that satisfies the condition of consumption efficiency requires that the marginal rates of substitution for the two individuals be equal. That is, we must have: $MRS_A = MRS_B$. This means, in an Edgeworth box framework, the indifference curves of the individuals should be tangential to each other i.e. the slopes of the indifference curves must be equal at the efficiency points (as at point 'b' in Figure 2.1). If the condition is not met i.e. if the indifference curves are intersecting and not tangential, then it will be possible to increase one person's utility without hurting another person and such an allocation cannot be termed 'efficient' (point 'a' describes such an allocation in Figure 2.1). By drawing a line through all such efficiency points (i.e. allocation points where the above condition is met) we obtain the 'consumption contract curve' (the line CC in Figure 2.2) or the 'Pareto efficient frontier'. Further, by plotting the utility levels attained at the efficiency frontier, we obtain the utility possibility frontier (Figure 2.3). Note that the two points of origin viz. A_0 and B_0

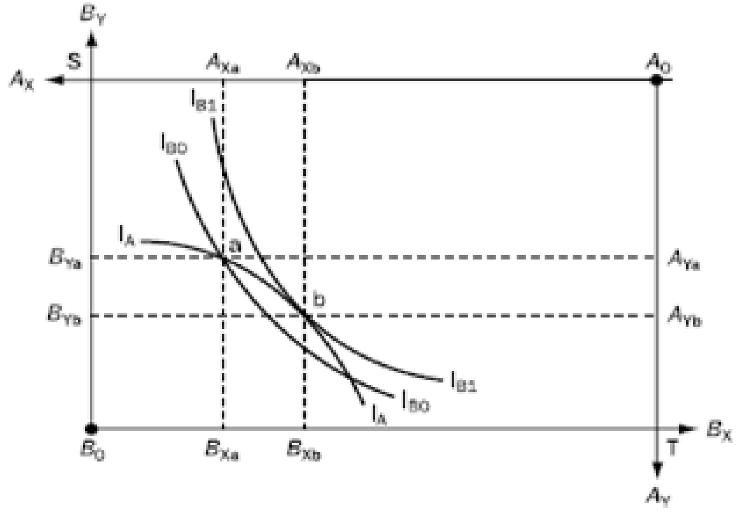

Fig. 2.1: Edgeworth Box and Efficiency in Consumption

Source: Perman et al., 2003 (page 107).

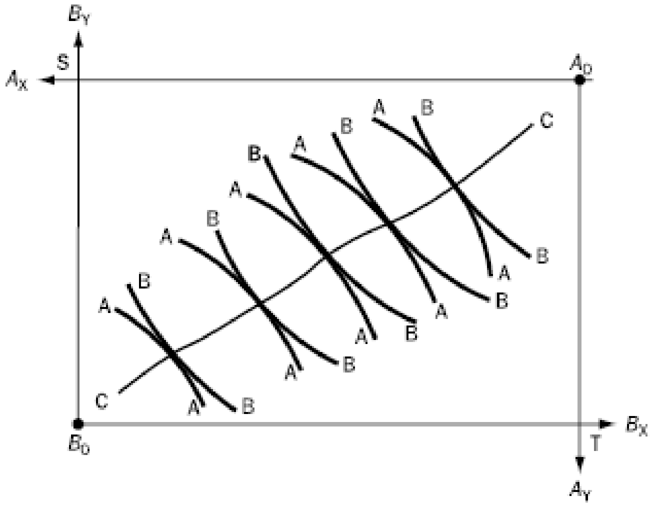

Fig. 2.2: Consumption Contract Curve

Source: Perman et al., 2003 (page 111).

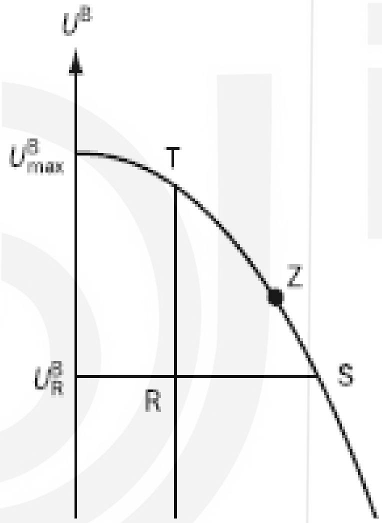

Fig. 2.3: Utility Possibility Frontier

Source: Perman et al., 2003 (page 111).

(in Figure 2.1) in the Edgeworth box lie on the contract curve. These are two special allocations, one where individual A has everything (A_0), and the other, where individual B has everything (B_0). Any reallocation from these two points necessarily makes one person worse off; hence these points are efficient.

2.3.2 Efficiency in Production

The condition for efficiency in production is similar to the one for efficiency in consumption (or exchange). Consider an economy which produces goods X and Y with a combination of inputs as capital (K) and labour (L). Efficiency in production requires that the marginal rate of technical substitution be equal in the production of both outputs. This means: $MRTS_X = MRTS_Y$. Graphically, we can again represent the condition as the point where two isoquants are tangent to each other in a production Edgeworth box. The production Edgeworth box along with isoquants and the efficient allocation is illustrated in Figure 2.4. If the above equality condition is not satisfied, it would be possible to reallocate the inputs to increase the output of one of the goods, without reducing the output of the other good. The locus of all efficient allocations in the production Edgeworth box gives us the ‘production contract curve’, which if represented in the output space, is simply the ‘production possibilities frontier’ (shown in Figure 2.4 as the curve $X_M Y_M$).

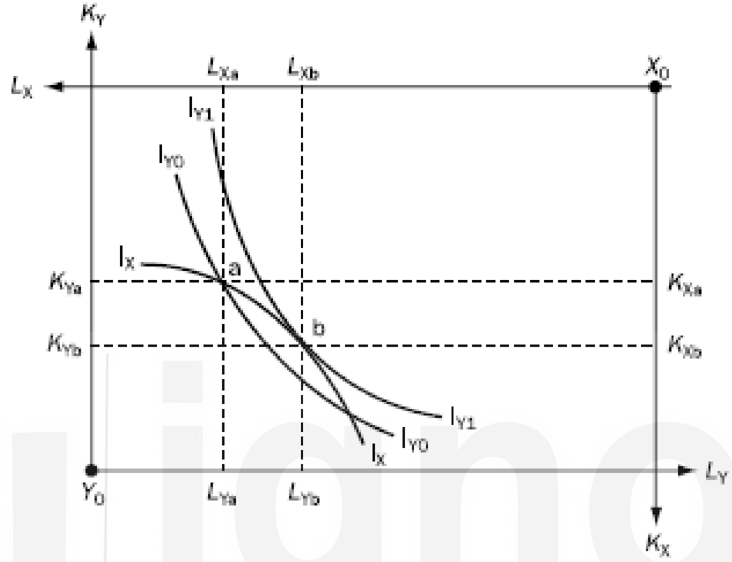

Fig. 2.4: Production Edgeworth Box and Efficiency in Production

Source: Perman et al., 2003 (page 108).

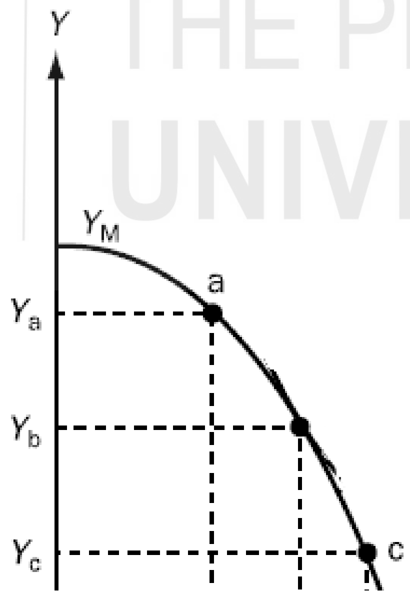

Fig. 2.5: Production Possibilities Frontier

Source: Modified from Perman et al. (2003), page 109.

2.3.3 Efficiency in Product-Mix

The product-mix efficiency condition is nothing but a combination of the above two conditions involving both production and exchange. Given the production possibilities frontier (PPF), the optimum allocation (i.e. the product mix where the slope of the PPF equals the MRS of the individuals in the economy), is where we achieve product mix-efficiency. Let us define MRT_L as the increase in the output of Y obtained by shifting a small amount of labour from use in the production of X to use in the production of Y. Similarly, we shall define MRT_K as the increase in the output of Y obtained by shifting a small amount of capital from use in the production of X to use in the production of Y. Using these two quantities, the condition for product-mix efficiency can be specified as:

$$MRT_L = MRT_K = MRS_X = MRS_Y$$

At such an allocation, the economy is simultaneously satisfying the conditions for production efficiency, consumption efficiency and product-mix efficiency. This is called as 'a fully efficient static allocation of resources'. The allocation at which product-mix efficiency is being achieved is depicted at point 'b' in Figure 2.6. The locus $X_M Y_M$ depicts the production possibilities frontier where the slope is equal to the marginal rate of transformation (MRT) between goods X and Y. At the three points denoted by a, b and c (all points lying on the frontier in general) the production efficiency condition is being satisfied i.e. we have $MRTS_X = MRTS_Y$ at each of these points. The society's 'indifference curve' (denoted by the curve marked I in Figure 2.6), has a slope of $MRS_{X,Y}^{A} = MRS_{X,Y}^{B}$ at point b. Since the slope of the production possibilities frontier MRT can be rewritten as the ratio of the marginal rates of transformation of labour and capital, the above condition implies that at the point of allocation satisfying the product-mix efficiency, the slope of the production possibilities frontier (MRT) should be equal to the slope of the indifference curves of the agents (MRS).

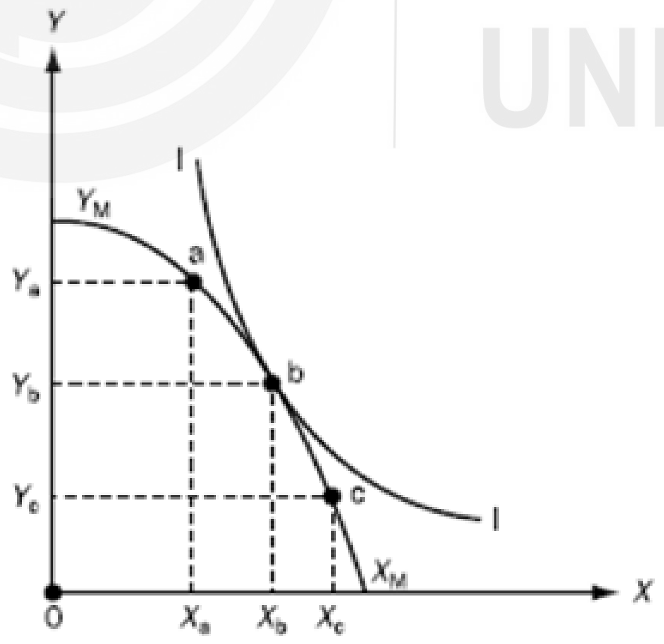

Fig. 2.6: Efficiency in Product-Mix

Source: Perman et al., 2003 (page 109).

Check Your Progress 1 [answer within the space given in about 50-100 words]

1) Distinguish between 'positive economics' and 'normative economics'.

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2) Illustrate the distinction in (1) above with an example.

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3) How is 'efficiency' defined? What are its three dimensions?

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4) How is a 'consumption contract curve' defined? Why is it also called 'Pareto efficient frontier'?

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2.4 EQUITY AND OPTIMALITY

In addition to efficiency, a desirable allocation of resources should fulfill the condition of *equity* as well. While no 'general' definition of equity exists, equity being a normative concept, it is often understood as 'fairness'. In the context of consumption and exchange, an allocation is considered equitable if no agent prefers another agent's bundle i.e. agent A does not 'envy' agent B's bundle. To take the simplest possible example, consider the two origins in the Edgeworth box. It was earlier explained that both these allocations are efficient. However, it is easy to see that these allocations are not equitable because, at either of these two allocations, one agent has none of the two goods. Note that equity is not the same as equality i.e. an equal distribution of resources need not always be equitable unless the preferences of the two individuals are identical.

2.4.1 Optimality

Combining the two concepts of efficiency and equity we can get the notion of social optimality i.e. the maximisation of society's welfare. Naturally, if we are to maximise social welfare, we first need to define a function that represents society's welfare. This is clearly the 'aggregate social welfare function' representing society's aggregate preferences. Since due to Arrow's impossibility result this is not possible to achieve, to proceed further, we need the assumption that such an aggregation of preference is somehow possible. With this assumption, the social welfare function can translate the utility levels of all the members of the society to a number in such a manner that the welfare function gives higher values of utility to the more socially desirable functions (e.g. health and education). The social welfare function, $W = W(U_A, U_B)$ can take different functional forms, although the typical restriction on the function is that it should be non-decreasing in the utility of each agent. This means:

$$\frac{\partial W}{\partial U_A} \geq 0; \frac{\partial W}{\partial U_B} \geq 0$$

Some of the standard social welfare functions are:

a) Utilitarian (Benthamite): $W = \Sigma_{i=1}^{n} U_i$

b) Rawlsian: $W = \min\{U_1, U_2, U_3 \ldots U_n\}$

c) Egalitarian: $W = \Sigma U_i - \lambda \Sigma_i [U_i - \min_i U_i]$

The choice of a welfare function determines what the society considers desirable as the choice necessarily entail value judgments. Thus, given a utility possibilities frontier, the highest social welfare function that is tangent to it provides the social optimal (i.e. point 'b' in Fig. 2.7).

The locus WW is one of the 'level curves' of the social welfare function where its 'indifference curves' are assumed to be continuous and bowed inward. The tangency of the indifference curve with the utility possibilities frontier (i.e. the bowed out curve in Fig. 2.7) is at point 'b'. At this tangency, since welfare is maximised, all three efficiency conditions (i.e. consumption efficiency, production efficiency and product-mix efficiency) are satisfied. Further, the slope of the indifference curve and the utility possibilities frontier are equalised. Clearly, given the shape of the social welfare indifference curves, points 'a' and 'c' would not maximise welfare and hence are not optimal.

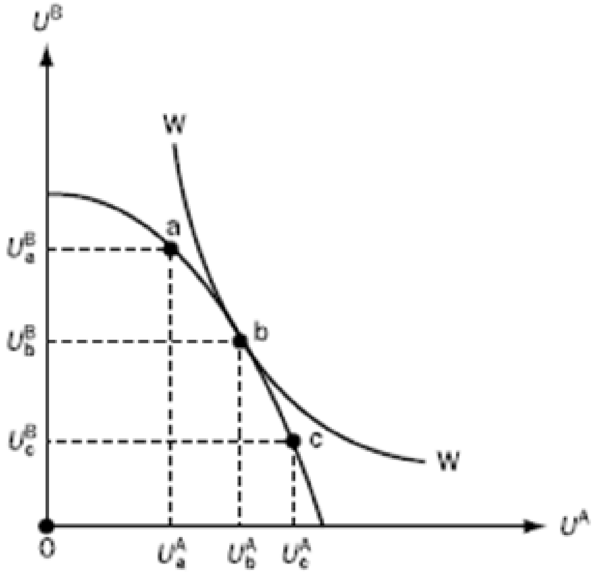

Fig. 2.7: Maximisation of Social Welfare

Source: Perman et al. 2003 (page 112).

2.5 ENVIRONMENTAL POLICY

The identification of the social welfare function (SWF) and the optimal allocations meeting the efficient conditions, ensures that the allocations are made in accordance with the social welfare values where a higher ranked allocation is chosen over a lower ranked one. This procedure, although is theoretically sound, pose problems in practice. First, as mentioned above, the construction of aggregate preferences is not straightforward. In addition, the choice of the specific form of the social welfare function being normative, guided by value judgements, one is prone to use methods of alternative allocations avoiding the need of referring to a SWF. In other words, in such situations, we would need criteria for evaluating alternative allocations. Towards this end, the present section discusses two criteria.

2.5.1 Pareto Improvement Criterion

The most well-known normative criterion, proposed by Italian economist Vilfredo Pareto, to judge whether a social change is 'welfare improving' is derived from the notion of Pareto efficiency. Recall that a Pareto efficient allocation is one where all mutually beneficial exchanges have been exhausted i.e. no one can be made better off without making someone else worse off. We can, therefore, define a 'Pareto improvement' as a change in which at least one person benefits with no one else losing. In Figure 2.3, a move from point R to point T, Z or S is a Pareto improvement since all these movements increases the utility of at least one agent without hurting anyone else. An important lacuna of this simple but restrictive criterion is that it is of limited practical use. Virtually all proposed reallocations would involve some 'gainers' and some 'losers' i.e. it is usually impossible for a policy to benefit everyone and hurt no one. In other words, the very need to evaluate policies arise from the fact that there will be always be 'winners' and 'losers' whose relative gains and losses are exactly what is needed to be weighed and compared.

2.5.2 Kaldor-Hicks Compensation Criterion

The Kaldor-Hicks compensation test is a better approach which tests whether the total social benefits exceed the total social costs. It thus lays the foundation for the cost-benefit analysis methodology widely used in policy evaluation. The Kaldor-Hicks evaluation criterion, also known as the compensation principle, identifies *potential* Pareto improvements and postulates that a given change is welfare-improving as long as the winners (i.e. those who gain from the change) could, *inprinciple*, fully compensate the losers, and still be better off. The potential compensation (or transfers) from the gainers to losers need not *actually* take place. In other words, even hypothetically, if these potential compensation payments are transacted, they would leave everyone at least as well off as before, while some agents would be better off. Such compensations would therefore be 'unanimously better', and hence yield a Pareto improvement. The following example illustrates this concept.

Consider an economy with a factory (i) and a fishery population in a downstream to the factory location (j) ($j \neq i$). Let us say that currently factory 'i' is creating pollution by releasing toxins in a nearby river which is affecting the life of fishes or the profits from fishing. The government decides to impose a tax on the factory to incentivise it to reduce its effluent discharge. Suppose factory i loses profits amounting to x due to the tax, while all other fisheries ($j \neq i$) gain by this same policy (since the reduced pollution will allow the fisheries to earn higher profits). Evaluating such a change through the lens of Pareto optimality would lead to the conclusion that this policy should not be implemented. However, if the gain of all fishery agents ($j \neq i$) is *greater* than x, then these agents could (collectively) transfer the amount x to the factory 'i' leaving all the agents better off. This is thus a potential Pareto improvement and is called as the Kaldor-Hicks test. An important limitation of the Kaldor-Hicks compensation test is that considerations of fairness are not necessarily addressed. For instance, consider an illustration as in Table 2.2 where two alternative allocations, 1 and 2, of goods X and Y are shown with both the agents A and B having the same utility function $U = \sqrt{XY}$. The move from allocation 1 to 2 reduces A's utility and increases B's utility.

Table 2.2: Compensation and Fairness

Agent	Allocation 1			Allocation 2		
	X	Y	U	X	Y	U
A	100	25	50	100	16	40
B	25	400	100	225	256	240

In allocation 2, B can potentially transfer 9 units of Y to A making A as well off as in allocation 1, and leaving B better off. Such a move would therefore pass the Kaldor-Hicks compensation test. Note however that the actual compensation need not take place and this reallocation has hurt the poorer of the two agents viz. A. In other words, the hypothetical compensation doesn't imply fairness and thus this evaluation criterion ignores the concern of distributional equity.

Check Your Progress 2 [answer within the space given in about 50-100 words]

1) What is a typical restriction on the 'social welfare function'? Why is it impossible to aggregate requiring us to make an assumption on this to proceed?

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2) Why is it generally difficult to pursue allocation option indicated by 'social welfare function'? What options are followed in such situations?

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3) What is meant by Pareto Improvement Criterion? What is its limitation?

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4) How is Kaldor-Hicks criteria superior to Pareto's Improvement Criterion? What is its limitation nonetheless?

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2.6 LET US SUM UP

Beginning with a distinction on the 'positive' and 'normative' concepts of economics, the unit introduces the concepts of 'efficiency, equity and optimality'. In the context of environmental policy considerations, since value judgements are involved and making a choice between alternative allocations is always involved (since adhering to the theoretical social welfare optimum is simply not possible in practical life), the concepts of Pareto Improvement Criterion and Kaldor-Hicks Compensation Criterion are discussed.

2.7 KEY WORDS

Welfare Economics	:	The branch of economic theory which investigates the nature of the policy recommendations that the economist is entitled to make.
Positive Economics	:	The use of economics to describe the world. It is a value-neutral analysis.
Normative Economics	:	The branch of economics that can be used to explain 'what should be'. It entails making value judgements.
Efficiency	:	An allocation of resources is efficient if it is not possible to make anyone better off, without hurting at least one person in the economy.
Equity	:	It is a normative concept, often understood as 'fairness'.
Optimality	:	At an optimal allocation, society's welfare is maximised.
Pareto Improvement	:	It is defined as a change where at least one person benefits, and nobody loses.
Kaldor-Hicks Compensation Test	:	This criterion postulates that a change is welfare-improving as long as the winners (those who gain from the change) could, in principle, fully compensate the losers, and still be better off.
Arrow's Impossibility Theorem	:	Arrow's result shows how aggregate preferences will be 'well-behaved' (i.e. complete, transitive and reflexive, and independent of irrelevant options), only under a dictatorship. In other words, the desired properties of a social welfare function cannot be achieved under a democracy. 'Aggregation' of individual preferences to construct social preferences is, thus, not a straightforward exercise.

2.8 SOME USEFUL BOOS AND REFERENCES

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2.9 ANSWERS/HINTS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) It is difference between explaining a situation on a 'what is' basis (i.e. positive economics) and explaining the same in terms of 'what should be' basis, the latter an ideal or efficient situation (i.e. normative economics) for which policy intervention to rectify the anomaly or imbalance is required.

2) If the environmental distortion on account of loss to marine life is limited to its quantification and explanation, it amounts to limiting the approach to making an assessment on environmental damage. If the approach is advanced to indicate what mitigating steps should be taken to reverse the damage to establish normalcy or stability by a policy intervention it becomes the solution by a normative economist or a normative evaluation.

3) In simple terms, efficiency means using the available resources optimally. This means, no other economic agent can be made better off without making at least one other economic agent worse-off. The three

dimensions of efficiency relates to efficiency in: consumption, production and product-mix.

4) In a two person's case, the consumption efficiency is attained at the point where the indifference curves for the two individuals are tangential to each other. By drawing a line through all such efficiency points, the curve we get is what is called as the 'consumption contract curve'. It is also called as the 'Pareto efficiency frontier' because, at these points 'one person's utility cannot be increased without hurting the utility of the other'.

Check Your Progress 2

1) Typical restriction is that 'aggregation of preferences at the society level' is possible. The impossibility restriction comes from the Arrow's impossibility theorem which states that: the desirable features of a social welfare function are inconsistent with a democracy. In other words, individual preferences cannot be aggregated in a perfect manner to construct one social preference.

2) Firstly, construction of aggregate preferences is impossible. Secondly, due to normative judgements involved, one is compelled to seek alternative allocation options. In such situations, evaluation criteria becomes useful.

3) The criterion requires that one's improvement should not be at the cost of the other. But in practice, this can rarely happen as all allocations makes some to gain and some to lose.

4) Kaldor-Hicks criteria is better since it considers the 'total social benefits' exceeds the 'total social costs'. It considers the compensating potential of gainers to the losers even if the actual compensation does not take place. A limitation is that consideration of fairness or distributional equity is not met.

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