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MODULE NAME: ENVIRONMENTAL ECONOMICS

LEVEL V: SEMESTER I: CREDITS 10

ADMINISTERED OPTION: MANAGEMENT OF FORESTRY&NATURAL ECOSYSTEM

LEARNING AND TEACHING STRATEGY: Lectures, seminars, individual and group practical problem solving exercises, case studies and field tour

CONTACT HOURS: **36 hours**

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COURSE ASSESSMENT;

Formative assessment-Group and individual assignments (60 % marks)

Summative assessment-Final examinations (40% marks)

UNIT 1: NATURAL RESOURCES ECONOMICS

CHAPTER I: DEFINITIONS OF KEY CONCEPTS

1.1. Space

Space is a polysemous concept. It corresponds first to a separation distance. Geographically, the space is a place or an area bounded or delimited. In that case, the term has different meanings:

- **Green Spaces**: a defined place and reserved for nature in the cities.

- u**rban space**: is the area occupied by a city or urban habitat

- **Rural Space**: it is an opposite of the urban space. It is mostly the countryside occupied by the fields.

- **Humanized Space**: It is a space occupied by human beings.

- **Represented Space**: how it is (in imagination) space.

- **Social Space**: It is an abstract term that is not a place but rather the social function of a place.
- **Vital Space**: minimum space needed to live Produced Space: space whose function has been designed by and for man example a town.

- Peri**pheral space**: Part of a country far from the centre. It also represents a portion of a country or region in which global resources are exploited for the benefit of the centre.

 Community space: Association for various reasons (political, economic) of several states or governments to form a community. This area is governed by laws and established rules in common. Example, East African Community.

 Geographic space: it is defined by latitude, longitude and altitude. For example Rwanda is between 1°04 and 2°51 latitude south, and between 28°45 and 31°15 longitude east.

 Mathematics space: an abstract space not defined but which represents a set of points (the abscissa and ordinate).

1.2. Region

It is also a polysemous concept. In geography is related to a division of the territory and to the public influence and perception. The use of the word depends on the objective assigned to it. Thus we can have:

 Administrative region: it is an official and political area which has power attributes.

 Industrial region: territory which economy depends on many industries found on that area.

 Natural region: expression meaning that the territory division was done based primarily on natural criteria: relief, climate, soil, Vegetation, hydrograph, topography etc.

 Historic region: space that has a common history Cultural region: space that has a common culture.

1.3. Environment

Environment refers to a set of the biotic and abiotic factors that condition the life of the plant and animal organisms. It is the physical, chemical and biologic factors influencing the living being of a given biotope.

The surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans, and the interaction between them.

The sum total of all the conditions and elements which make up the surroundings and influence the development and actions of an individual. The external surroundings of an organism, consisting of biotic (living) and abiotic (non-living) factors which affect the life of all the organisms within it. The environmental conditions of earth are ideal for life to exist and steadily evolve within. In short it is everything that affects an organism during its life time.

1.4. The natural systems spheres

The natural systems encountered in physical geography operate within the four great realms, or spheres, of the Earth. These are the atmosphere; the geosphere, the hydrosphere, and the biosphere.

Atmosphere

Atmosphere is the gaseous layer that surrounds the Earth. It receives heat and moisture from the surface and redistributes them, returning some heat and all of the moisture to the surface. It supplies vital elements needed to sustain life forms.

Geosphere

The solid part of the earth consisting of the crust and outer mantle

Hydrosphere

Hydrosphere is the liquid realm of the Earth is principally the mass of water in the world"s oceans. It also includes solid ice in mountain and continental glaciers. Water occurs as a gaseous vapor, liquid droplets, and solid ice crystals. In the geosphere, water is found in the uppermost layers in soils and in ground water reservoirs.

Biosphere

It is called also the life layer. It includes the surface of the lands and the upper 100 meters of the ocean. Biosphere is the part (or region) of the planet that contains the set of the living being and in which life is permanently possible. It is the global sum of all ecosystems; it is the zone of life on the Earth. It is the thin layer of air (atmosphere), water (hydrosphere), soils and rocks (lithosphere) that surround the Earth and contains the conditions which support life. It is a part of the planet where life is permanently supported. It contains the air which supports life.

1.5. Ecology and Ecosystem

Ecology (of the Greek "**oïkos**" = habitat and "**logo**s" = science) can be define as the science that studies the relationships between the living things and the natural habitat where they live. **Ecology** is the study of the relationships between organisms and their environment and among the various ecosystems in the biosphere. We should well distinguish between Biologic ecology, Geographical ecology, and Human ecology. Ecology is the study of the relationships within the Biosphere and between it and the other spheres.

Ecosystem

An **ecosystem** is a self-regulating association of living plants and animals and their physical environment. In an eco-system, a change in one component causes changes in others, as systems adjust to new conditions. Natural ecosystems are open systems for both energy and matter, with almost all ecosystems boundaries functioning as transition zones rather than as sharp demarcations. An ecosystem is a complex of many variables all functioning independently yet in convert, with complicated flows of energy and matter. It includes both biotic (living) and abiotic (non-living) components. Nearly all depend on an input of solar energy. The few limited ecosystems that exist in dark caves or on the ocean floor depend on chemical reactions (chemosynthesis). The abiotic flows in an ecosystem include gaseous and sedimentary nutrient cycles.

An ecosystem is a group of organisms and their environment which are interrelated and dependent on each other.

Compositions of an ecosystem

- Abiotic
- Biotic
- Climatic Inorganic
- Organic
- Producer Consumer
- Decomposer
- Photosynthetic
- Chemosynthetic Herbivores Carnivores
- Temperature, humidity,light, etc.
- Water, oxygen, mineral matters,CO2…
- Sugar, protein, humus …

- An ecosystem(Detritivores :Microbes/animals)

1.6. Technology

Technology refers to the ways in which humans do and make things with materials and energy. Humans will use technology to provide the food, shelter, and goods that they need for their well-being and survival. The challenge is to interweave technology with considerations of the environment and ecology such that the two are mutually advantageous rather than in opposition to each other.

1.7. LEVELS OF ORGANIZATION

Genes: distinct pieces of DNA that determine the characteristics an individual plays. There are genes for structures like leaf structures or feather color, behaviors like cricket chirps or migratory activity, physiological processes like photosynthesis or muscular contractions.

Individuals: the fundamental units of populations, communities, ecosystems and biomes which can complete its life cycle independently

Species: A group of organisms capable of interbreeding freely with each other but not with members of other species (a closed "gene pool".). A species is a group of similar individuals having a common origin and a continuous breeding system. It is an individual belonging to a group of organisms (or the entire group itself) having common characteristics and usually are capable of mating with one another. At present there are almost 250,000 to 300,000 species of plants and nearly one million species of animals. This does not include all living population. It is estimated that 10 to 20 percent more plant species should be added and rather higher percentages of animals. Some works also consider that only about half the existing species of insects, for example, have yet been described.

Population: the number of individuals of a single species that occupy a defined area at a given time

Community : all the individuals of all species that occupy a defined area at a given time

Ecosystem : the community plus all the non-living things (soil, air, water, climate, etc.) that occupy a defined area at a given time

Habitat is the specific physical location of an organism. The type of environment in which an organism resides is biologically adapted to its live. Most species have specific habitat requirements with definite limits and a specific regimen of sustaining nutrients.

Niche refers to the function or occupation of a life form within a given community. It is the way an organization obtains and sustains the physical, chemical, and biological factors it needs to survive. An individual species must satisfy several aspects in its niche. Among these are habitat niches, a trophic (food) niche, and a reproductive niche. Similar habitats produce comparable niche. In a stable community, no niche is left unfulfilled.

Biotope is an area of uniform environmental conditions providing a living place for a specific assemblage of plants and animals. Biotope is almost synonymous with the term habitat, but while the subject of a habitat is a species or a population, the subject of a biotope is a biological **community**. It is a usually small or well-defined area that is uniform in environmental conditions and in its distribution of animal and plant life.

Example: . Animals, unlike plants, tend to be very definite with this term because some plants can cross-breed with other fertile plants. In the diagram above, you will notice that Gill, the goldfish, is interacting with its environment, and will only crossbreed with other gold fishes just like her.

Population: A group of individuals of a given species that live in a specific geographic area at a given time. (example is Gill and his family and friends and other fishes of Gill‟s species) Note that populations include individuals of the same species, but may have different genetic makeup such as hair/eye/skin colour and size between themselves and other populations.

Community: This includes all the populations in a specific area at a given time. A community includes populations of organisms of different species. In the diagram above, note how populations of gold fishes, salmons, crabs and herrings coexist in a defined location. A great community usually includes biodiversity.

Ecosystem: As explained in the pages earlier, ecosystems include more than a community of living organisms (biotic) interacting with the environment (abiotic). At this level note how they depend on other abiotic factors such as rocks, water, air and temperature.

Biome: A biome, in simple terms, is a set of ecosystems in a geographic area.

Biosphere: When we consider all the different biomes, each blending into the other, will all humans living in many different geographic areas, we form a huge community of humans, animals and plants, in their defined habitats. A biosphere is the sum of all the ecosystems established on Earth.

1.8. Environmental/ natural resources

Environmental resources (natural resources) are the materials that occur naturally in the environment and they have use value naturally or after being subject to certain degree modification or process. Or these are sources of raw materials used by the society (McKinney and Schoch, 1996). On the other hand Waugh (1995) defined natural resources as features which are needed and used by people. Literally the term resources is synonymous to natural resources, some individuals broaden the meaning to even accommodate human resources. These materials include all types of matter and energy that are used to build and run society. These include materials such as soil, minerals, water, coal and all other naturally occurring materials. The materials that have been located but cannot be extracted profitably at the present time are simply called Reserves.

1.9. Types of natural resources

The natural resources are mainly grouped into two major categories, namely

i) Renewable resources and

ii) Non-renewable resources

Renewable Resources

These are resources that can be replaced within few humans generation. These resources have ability to replenish themselves after use. Examples of these resources include timber, food and most of alternative sources of energy such as solar power, biomass, wind power and hydropower.

Non-renewable resources

These are the resources that cannot replenish themselves within a few human generations.

The phrase „few human generations‟ here is very essential because some resources are replaceable over a very long geologic time scales. For example oil, soil, coal and some metallic mineral deposits may form again if we wait for thousands to hundreds of millions of years. However, these rates of renewal are so many thousands of times slower than the rates of use that, for all intents, they are nonrenewable on a human time scale.

The concept of renewability is sometimes blurred (unclear). Very old ground water in desserts may take centuries or even many years to replace themselves, while ground water in rainy tropical areas may be replaced in a few days. Thus deep ground water in desserts is sometimes termed „fossil ground water‟ which is in a way non-renewable resource.

NOTE: The major concern of the earth as whole currently is to switch from the use of non-renewable resources to use of more environmental friendly renewable resources i.e use of wind energy as opposed to fossil energy which is so unfriendly into the environment. Their use therefore pollute environment Since non-renewable resources have time limit in terms of their use, prices tend to fluctuate a great deal and hence destabilizing many economic processes.

Study questions

1. Use of renewable natural resources is friendlier to environment compared to nonrenewable resources. Discuss

2. Differentiate the natural resources from the reserves.

3. Renewability of a resource is sometimes blurred. Discuss

4. Differentiate renewable resources from non-renewable resources.

5. Briefly explain the history of natural resources management in world and Africa?

6. Write a short note on the following terms: region, space, Environment, natural systems spheres, Ecology and Ecosystem, Technology, levels of organization, Habitat, Niche. Biotope

CHAPTER 2: ROLE OF ECONOMICS IN NATURAL RESOURCES MANAGEMENT

2.1. Introduction

As society moves through the 21st century, it faces an important challenge: to protect and preserve the earth‟s resources continues to develop economically. The rapid growth and advancing technology that began in earnest with the industrial revolution have taken a toll on the natural environment. Mass transport, manufacturing process, telecommunications, and synthetic chemicals are responsible both for the highly advanced lifestyle that society enjoys and for much of the environmental damage it now faces. We know that the trade-off between economic growth and environmental quality was significant.

An important element is to understand the critical relationship between economic activity and nature and to use that knowledge to make better and wiser decisions. Of course there will be some amount of trade–off precisely what economic theory conveys. We cannot expect to have perfectly clean air or completely pure water, nor can we continue to grow economically with no regard for the future. But there is a solution, although it is a compromise of sorts. We first have to decide what level of environmental quality is acceptable and then make appropriate adjustments in our market behavior to sustain that quality as we continue to develop as a society.

The adjustment process is not an easy one, and it takes time. As a society, we are still learning about nature, about market behavior, and about the important relationship that link the two together. What economics contributes to this learning process are analytical tools that help to explain the interaction of markets and the environment, the implications of that relationship and the opportunities for effective solutions.

One of the most pervasive applications of economic theory is that it logically explains what we observe in reality. For example, through microeconomic analysis we can understand the behavior of consumers and firms and the decision making that defines the marketplace. This same application of economic theory can be used to analyze environmental problems, why they occur and what can be done about them? Stop to consider how pollution or resource depletion comes about, not from a sophisticated scientific level, but from a fundamental perspective. The answer? Both arise from decisions made by households and firms. Consumption and production draw on the earth‟s supply of natural resources. Furthermore, both activities generate by-products that can contaminate the environment. This means that the fundamental decisions that comprise economic activity are directly connected to environmental problems. To illustrate this relationship, we begin by presenting a basic model of economic activity. Then, we expand the model to show exactly how this connection arises.

2.2. Circular flow model

The basis for modeling the relationship between economic activity and environment is the same one that underlies all of economic theory, the circular flow model, typically, this is the first model students learn about in introductory economics. First consider how the flows operate, holding all else constant. Notice how the real flow runs counterclockwise between the two market sectors, households or consumers and firms or producers. Producers supply resources or factors of production to the factor market, where they are demanded by firms to produce goods and services. These commodities are then supplied to the output market, where they are demanded by households. Running clockwise is the money. The exchange of inputs in the factor market generates an income flow to households and that flow represents costs incurred by firms.

Analogously, the money flow through the output market shows how households‟ expenditures on goods and services are revenues to firms. Now think about how the volume of economic activity and hence the size of the flow are affected by such things as population growth, technological change, labor productivity, capital accumulation and natural phenomena such as drought or floods. For example holding all else constant, technological advances would expand the productive capacity of the economy, which in turn would increase the size of flow. Similarly, a population increase would lead to a greater demand for goods and services, which would call forth more production and lead to a larger circular flow.

Notice that by analyzing how the flows operate and how the size of an economy can change, we can understand the basic functioning of an economic system and the market relationships between households and firms. However the model does not explicitly show the linkage between economic activity and the environment.

2.3. Materials balance model

The explicit relationship between economic activity and the natural environment is. Notice how the real flow of the circular flow mode is positioned within a larger schematic to show the connections between economic decision and the natural environment.

Flow of resources

The linkages between the upper block representing nature and two market sector, paying particular attention to the direction of the arrows. Notice that one way an economic system is linked to nature is through a flow of materials or natural resources that runs from the environment to the economy, specifically through the household sector. (Recall that by households are the owners of all factors of production including natural resources). This flow describes how economic activity draws on the earth‟s stock of natural resources such as soil, minerals and water.

Flow of residuals

A second set of linkages runs in the opposite direction from the economy to the environment. This flow illustrates how row materials entering the system eventually are released back to nature as by-products or residuals. Most residuals are in the form of gases released into the atmosphere and in short run most are harmful. In fact, some are absorbed naturally through what is called the assimilative capacity of the environment. For example, carbon dioxide emissions from the combustion of fossil fuels (oil, coal, and natural gas) can be partially absorbed by the earth‟s oceans and forests. Other released gases are not easily assimilated and may cause harm, even in the short term. There are also liquid residuals such as industrial wastewaters and solid residuals such as municipal trash and certain hazardous wastes, all of which are potential threats to health. Notice that in the figure there are residual outflows, one leading from each of the two market sectors, meaning that residuals arise from both consumption and production activity.

It is possible to delay, though not preventive, the flow of residuals back to nature through recovery, recycling and reuse. Notice in the model that there are inner flows running from the two residual outflows back to the factor market. These inner flow show that some residuals can be recovered from the stream and either recycled into another usable from or reused in their exiting form. For example Germany‟s BMW group has made advances in automobile design to facilitate recycling once a vehicle has reached the end of its economic life.

Although recycling efforts are important, keep in mind that they are only short time measures, because even recycled and reused products eventually become residuals that returned to the nature. Indeed what the materials balance model shows that all resources drawn from the environment ultimately are returned there in the form of residuals. The two flows are balanced a profound fact that is supported by science.

2.4. Using science to understand the materials balance

According to the first law of thermodynamics (The branch of physics concerned with the conversion of different forms of energy) matter and energy can neither be created nor destroyed. Applying this fundamental law to the materials balance model means that in the long run, the flow of materials and energy drawn from nature into consumption and production must equal the flow of residuals that run from these activities back into the environment. Put another way when raw materials are used in economic activity, they are converted into other forms of matter and energy, but nothing is lost in the process. Over the time, all these materials become residuals that are returned to nature. Some arise in the short run, such as waste materials created during production. Other resources are first transformed into commodities and do not enter the residual flow until the goods are used up. At this point, the residuals can take various forms such as carbon monoxide emissions from gasoline combustion or trash disposed in municipal landfill. Even if recovery does take place, the conversion of residuals into recycled or reused goods is only temporary. In the long run, these too end up as waste.

There is one further point. Because matter and energy cannot be destroyed, it may seem as though the materials flow can go on forever. But the second law of thermodynamics states that nature's capacity to convert matter and energy is not unlimited. During energy conversion, some of the energy becomes unusable. It still exists but it is no longer available to use in another process. Consequently the fundamental process on which economic activity depends is finite.

These scientific laws that support the materials balance model communicate important, practical information to society. First, we must recognize that every resource drawn into economic activity ends up as residual, which has the potential damage to the environment. The process can be delayed through recovery but not stopped. Second, nature's ability to convert resources to other forms of matter and energy is limited. Taken together, these assertions provide a comprehensive perspective of environmental problems and the important connections between economic activity and nature.

2.5. Basic structure of interaction between the ecosphere and the anthroposphere

The origins of global change are to be found in dramatic developments within the anthroposphere (population growth, expansion of technical industrial civilization, the North-South divide, etc.), which radiate via the "environment" into the ecosphere and threaten to change the character of the planetary ecosystem (= totality of life on Earth + directly used, influenced or influencing abiotic components). This is all the more striking given that humanity is in fact "insignificant" as a physical factor in the Earth System. Functioning as a relay, however, i.e. through targeted diversion of energy and material flows, it alters the structure and performance of fragile but significant subsystems in the ecosphere – with unintended consequences for the stability and availability of the life support system on which our survival depends.

Rational action that seems reasonable within the local context can lead to global and historical folly. A "holistic" perspective of the human environment is thus required – how else are we to identify and avoid pathways of civilizational development which could conceivably disrupt the dynamical equilibrium of the planetary ecosystem?

On the most aggregated level of the synopsis, the Earth System is composed of the ecosphere and the anthroposphere, whose metabolisms are intricately linked. the anthroposphere is symbolically removed from the ecosphere, without the connective "threads" being cut, however. Presenting the relationship in this way means to identify and emphasise the main interactions between the two spheres.

In this diagram, the ecosphere itself consists of the following subsystems:

- **Atmosphere**: Environmentally relevant are the troposphere (lowest layer, the main reservoir of the gases relevant for life on Earth and the theatre for weather), and the stratosphere (vertically stable layer above the troposphere containing the ozone shield against UV-B radiation).

- **Hydrosphere**: Encompasses the total mass of free water contained in the oceans, terrestrial reservoirs (lakes, rivers, soils, etc.) and organic substances. The structure of the major ocean currents is of particular significance for the planetary ecosystem. A crucial component of the hydrosphere is the cryosphere, i.e. the frozen waters of the polar ice-caps, sea ice, glaciers and permafrost soils. Only a minute proportion of the hydrosphere exists as freshwater, most of which is frozen.

- **Lithosphere:** Refers to the Earth"s crust, including all biogenic depositions such as sediments or fossil fuels. The lithosphere is the foundation, the most important source of nutrients and – in addition to the sun – the engine driving the evolution of the ecosphere (volcanic activity, plate tectonics, etc.).

- **Pedosphere** :Comprises soils as intersectional space between lithosphere, hydrosphere, atmosphere and biosphere, possessing a specific character of its own and forming the substrate for terrestrial vegetation.

- **Biosphere** :Encompasses all life on Earth, which in turn consists of the flora and fauna of the continents and oceans, and micro-organisms (bacteria, viruses).

Within the ecosphere, myriads of exchange processes occur between the various sub-spheres listed above.

The anthroposphere refers to humanity in the sense of a population, together with all of its activities and products.

The principal indicators are:

- use of natural resources in economic processes,
- emissions of (contaminant) substances and the manipulation and degradation of protected interests through economic activity including transport systems,
- Alterations to natural systems (water, vegetation cover, soils, etc.) through direct action by human beings or in the course of ensuring their subsistence (housing, fuel requirements, etc.),
- protection of landscapes, ecosystems or species through legal measures,
- consumption of vital substances (air to breathe, drinking water, trace elements, etc.) and aesthetic stimulation etc. by individuals,
- Effects of climate on population, traffic and economies.

The solid outer section of the Earth is designated as the lithosphere or petrosphere. It comprises the continental and oceanic crusts and parts of the Earth"s upper mantle. The dynamics and composition of the lithosphere, with its huge mass, are hardly subject to change by humans. However, it does serve as a source of raw materials (coal, oil, natural gas, ore, gravel, sand, ground water, etc.) and is used as a disposal site for wastes of all kinds. The lithosphere"s outer zones of contact to the other spheres, on the other hand, represent a sensitive area which is of great significance for living organisms and can be greatly changed by humans: these are soils and sediments.

Soils cover large portions of the ice-free surface of the continents like a thin skin. In a zone that may have a thickness ranging from a few centimeters to several meters, the lithosphere, hydrosphere, atmosphere and biosphere form the pedosphere. Thus defined, soils represent structural and functional elements of terrestrial ecosystems.

Soil diversity contributes decisively to the diversity of terrestrial ecosystems as well as to the characteristics of landscapes.

Sediments are the biotically active zones in aquatic areas corresponding to soils. They are, therefore, frequently referred to as underwater soils, although they are extensively free of oxygen due to the lack of atmospheric components. They have also great importance for biogeochemical cycles and similar processes take place in sediments as in soils.

2.6. Soil functions

The significance of soils and sediments for plants, animals, microorganisms and humans as well as for the balance of energy, water and elements can be summarized on the basis of three overriding functions:

a) Habitat function

Soils are the habitat and basis of life for a wide variety of plants, animals and microorganisms. Soil organisms are, in their entirety, the media for synthesis, conversion and decomposition of substances in the soil. Due to their diversity, they influence the stability of ecosystems by decomposing toxic substances, delivering substances for growth and generating a flowing balance between processes of synthesis and decomposition. Soils are the basis for the primary production of terrestrial systems and thus the basis for existence of human societies as well.

b) Regulation function

This includes transport, transformation and accumulation of substances. Via various processes, soils are agents for the exchange of substances between the hydrosphere and atmosphere as well as neighboring ecosystems. The regulation function comprises all abiotic and biotic internal processes in the soil which are triggered by material inputs and nonmaterial influences. As subfunctions, they include the buffer capacity for acids, the storage capacity for water, nutrients and harmful substances, the recycling of nutrients, the detoxification of harmful substances, the destruction of pathogens as well as the balancing capacity for matter and energy.

c) Utilization function

Soils are locational components of agricultural and forestry production (production function). This refers to the capacity of supplying primary producers (plants) with water and nutrients and serving as their rhizosphere (root sphere). Particularly in view of the aspect of soil management in agriculture and forestry, this also applies to the aim of producing biomass that is usable for people (human and animal food, regrowing raw materials).In addition; people utilize the soil in many different ways. For example:

- as a site for obtaining raw materials (production function),
- as an area for settlement, transport, supply and recreation (carrier function),
- as an area for industrial use (carrier function),
- as an area for waste disposal (carrier function),
- as a gene pool (production and information function),
- as an indicator of productivity (information function),
- as an archive for natural and cultural history (cultural function). Soils as vulnerable systems

Soils are open and thus changeable systems. They exchange energy, matter and genetic information with their environment and are thus susceptible to all forms of external stress. This situation makes soil degradation a global environmental problem. The resulting changes frequently take place very slowly or are not easily perceptible. Once damage occurs, however, it can often only be remedied over very long periods of time. Soil losses must, therefore, be regarded as irreversible if one does not set geological time scales. Of the soil covering approx. 130 million km2 of the ice-free surface of the Earth, nearly 20 million km2, i.e. 15%, display obvious signs of degradation caused by humans. This is the result of a comprehensive study carried out within the framework of the United Nations Environmental Programme (UNEP) by the International Soil Reference and Information Centre (ISRIC) (Oldemann et al., 1991). Erosion by water, with a figure of 56%, makes up the largest portion of this soil degradation, followed by wind erosion with 28%, chemical degradation with 12% and physical degradation with 4%. These figures do not include degradation of forest soils.

From the recognition that soils play an important role in terrestrial ecosystems, that reserves are limited and that only a relatively small percentage of soils can be used for agricultural purposes, it follows that soils and the organisms living in and from them merit a high degree of protection. Therefore, the principle of precautionary protection of the environment must fundamentally be given high priority with regard to the conservation of soils.

Chapter Summary

In this chapter it is observed that the subject matter of ecology deals with the study of the interrelationships between living organisms and their habitat, the physical environment. Since the key issue is always interrelation, the concept of system is fundamental in any serious ecological study. Using the ecosystem as a framework, ecologists try to explain the general principles that govern the operation of the biosphere.

The basic lessons of ecology are several; and from a purely biophysical perspective, the most pertinent ones are:

1 No meaningful hierarchical categorizations can be made between the living and nonliving components of an ecosystem because the physical environment and the living organisms are mutually interdependent. 2 Energy is the lifeblood of an ecosystem. 3 The operation of the natural ecosystems is characterized by the continuous transformation of matter and energy. This may be manifested in several forms, such as production, consumption, decomposition and the processes of life themselves. 4 Any transformation of matter-energy is governed by certain immutable natural laws, two of which are the first and second laws of thermodynamics. The first law informs us that there are finite stocks of resources; the second law reminds us that the continuing operation of any system requires a flow of energy from an external source. 5 The species composition of a natural ecosystem undergoes gradual and evolutionary changes (succession). A mature ecosystem supports a great number of interdependent species. 6 Ecosystems, however, are also systems of discontinuous changes. Disruptions resulting from external environmental factors (such as global warming) which affect extensive areas could have significant detrimental effects on species composition and the structure and functioning of the ecosystem.

• Furthermore, in this chapter attempts were made to highlight some of the important links between ecology and economics. Among them are:

1 Economics and ecology deal with common problems. That is, both disciplines deal with transformation of matter and energy. This interpretation is quite consistent with the meaning of the common prefix of these two disciplines—that is, the Greek word "eco," which literally means the study of households. 2 However, this means that, like that of the natural ecosystem, the operation of the human economy is characterized by continuous transformation of matter and energy. For this reason, the human economy must depend on the earth's ecosystems for its basic material and energy needs. The dependence of the economic system on the natural ecosystems is so complete that the human economy can rightfully be regarded as nothing more than a subsystem of the entire earth's ecosystem (Georgescu-Roegen 1993; Boulding 1993).

• Beyond this, on the basis of the materials discussed in this chapter, we were able to infer the following:

1. Natural resources are finite. In this regard, the human economy is "bounded" by a non growing and finite ecological sphere. The implication of this is that nature cannot be exploited without limits.

2. Pollution is an inevitable by-product of any economic activity.

3. There are definite limits to technology. 4 Throughout history, the tendency of humanity has been to act as the breaker of climaxes, by either a simplification of the ecosystem and/or the introduction and disposal of industrial wastes.

Review and discussion questions

1. Explain in details the role of economics in natural resources management?

2. Describe in details the links between ecosphere and anthroposphere

3. **Describe the soil functions**

4. Briefly describe the following ecological concepts: ecosystem, primary producers, consumers, decomposers, photosynthesis, nitrogen fixation, ecological succession, biodiversity, ecological

resilience, pioneer stage, climax stage, the first and second laws of thermodynamics, entropy, monoculture.

5. State True, False or Uncertain and explain why.

(a) Energy is the ultimate resource. (b) A climax ecosystem is complex, diverse, resilient and, as such, stable. (c) In principle, an ecosystem can function without the presence of consumers. (d) Ecology and economics deal with production and distribution of valuable resources among complex networks of producers and consumers. Energy and material transformations underlie all these processes, and therefore both ecology and economics must comply with the fundamental constraints imposed by thermodyamics.

6. In his classic article “The Historical Roots of Our Ecological Crisis”, (1967) Lynn White, Jr., asserted that “we shall continue to have a worsening ecological crisis until we reject the Christian axiom that nature has no reason for existence save to serve man.” Do you agree or disagree? Explain your position.

7 “Economists are fond of saying that we cannot get something for nothing. The entropy law teaches us that the rule of biological life and, in man’s case, of its economic continuation is far harsher. In entropy terms, the cost of any biological or economic enterprise is always greater than the product. In entropy terms, any such activity necessarily results in a deficit” (GeorgescuRoegen 1993:80). Provide a brief explanation of the essential message(s) conveyed by this remark.

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CHAPTER THREE: ENVIRONMENTAL AND RESOURCE ECONOMICS

3.1: Introduction

SCOPE AND NATURE As a subdiscipline of economics, environmental and resource economics started in the 1960s—the early years of the so-called environmental movement. However, despite its brief history, over the past three decades it has become one of the fastest-growing fields of study in economics. The growing popularity of this field of inquiry parallels the increasing awareness of the interconnectedness between the economy and the environment—more specifically, the increasing recognition of the significant roles that nature plays in the economic process as well as in the formation of economic value. The nature and scope of the issues addressed in environmental and resource economics are quite varied and all-encompassing. Below is a list of some of the major general topics addressed in this field of study:

- the call for a renewed perception and understanding of resource scarcity;
- the need to reestablish the disciplinary ties between ecology and economics;
- the causes of environmental degradation;

• the difficulties associated with assigning ownership rights to environmental resources;

• the trade-off between environmental degradation and economic goods and services;

• assessing the monetary value of environmental damage;

• the ineffectiveness of the market, if left alone, in allocating environmental resources;

• the difficulties associated with measuring the size of resource stocks of biological and geological origin;

• economic indicators of natural resource scarcity and their limitations;

• public policy instruments that can be used to slow, halt and reverse the deterioration of environmental resources and/or the overexploitation of renewable and nonrenewable resources; the macroeconomic effects of environmental regulations and other resource conservation policies;

• the extent to which technology can be used as a means of ameliorating resource scarcity—that is, limits to technology;

• the extent to which past experience can be used to predict future events that are characterized by considerable economic, technological and ecological uncertainties;

• population problems: past, present and future;

• the interrelationships among population, poverty and environmental degradation in the developing countries of the world;

• resource problems that transcend national boundaries, and thus require international cooperation for their resolution; • the limits to economic growth;

• ethical and moral imperatives for resource conservation—concerns for the welfare of future generations; • the necessity and viability of sustainable development.

This list by no means exhausts the issues that can be addressed in environmental and resource economics. However, the issues contained in this list do provide important clues concerning some of the fundamental ways in which the study of environmental and resource economics is different from other subdisciplines in economics. First, the ultimate limits to resource availability are imposed by nature. That is, their origin, interactions and reproductive capacity are largely governed by nature. Second, most of these resources have no readily available markets: for example, clean air, ozone, the genetic pool of a species, the price of petroleum fifty years from now, etc. Third, time plays a very important role in the allocation and distribution of these resources. The major problem is generally recognized as “How long and under what conditions can human life continue on earth with finite stocks of in situ resources, renewable but destructible resource populations, and limited environmental systems?” No serious study in environmental and resource economics can be entirely static. Fourth, no serious environmental and resource economic study can be entirely descriptive. Normative issues such as intergenerational fairness and distribution of resources between the poor and rich nations are very important. Fifth, uncertainties are unavoidable considerations in any serious study of environmental and natural resource issues. These uncertainties may take several forms, such as prices, resource stock size, irreversible environmental damage, or unexpected and sudden resource depletion.

• Natural resources are scarce and as such they should be economized.

• Natural resources are essential factors of production. An economy cannot produce goods and services without the use of a certain minimum amount of natural resources. However, to the extent that resources are fungible, natural resources need not be seen as the sole or even the primary factor in determining an economy’s production capacity. For example, the economy of Costa Rica can, in principle, run without its forestland, provided sufficient amounts of labor and other capital assets are available to offset its absence. • Economists’ view of natural resources is strictly anthropocentric; that is, from an economic point of view natural resources have no intrinsic value.

• The economic value of a natural resource is ultimately determined by consumers’ preferences.

• Consumers’ preferences are best expressed by a market economy, and for that reason the market system is the preferred institution for allocating resources.

• Scarcity of resources (including natural resources) is continually augmented by technological advances.

• In the human economy, the value of natural resources is determined by the flow of services that these resources contribute to the economy. For example, Costa Rica's forestland is valued to the extent that it serves as a continuous source of basic resources such as hardwood, drinking water, a place to attract tourists or in which to conduct scientific experiments, and so on.

• This emphasis on the flow of resources rather than the stock of natural resources has two profound implications:

1 The link between the flow of matter-energy in the economic process and the natural environment is simply overlooked. This fact, together with the standard anthropocentric view of natural resources, is likely to undermine the total value (economic plus noneconomic) of natural resources. For example, a justification for more conservation of Costa Rica's forestland would customarily be evaluated on the basis of its market (commercial) values. This approach, however, provides no explicit consideration of the fact that the forest is also home to many rare plant and animal species which are important for the ecological integrity of the forest but have little commercial value.

2 The fact that the economic process continually depends on the natural world for both the generation of raw material "inputs" and the absorption of waste "outputs" is simply taken for granted (Georgescu-Roegen l993).

3.2: Consumers and Suppliers' theory

Consumers and producers occupy an important place in a market-oriented economy. These entities are viewed as being single-minded in their economic behavior, pursuing their own self-interest. For consumers, this means maximizing the level of satisfaction (utility) they attain from the consumption of final goods and services. For this reason, at least at the aggregate level, the more goods and services are available in the economy, the higher the level of satisfaction attained by the average citizen of a society. From the producers' viewpoint, self-interest implies ensuring that they earn the "highest" possible profit from the services they render to society. As we shall see shortly, producers' profit is affected by the degree of competition that exists in the market. Note that the producers' desire to enrich themselves is consistent with the consumers' desire to maximize their utility. After all, other things being equal, higher profit would enhance producers' ability to buy more goods and services, and thus increase utility. It is in this sense that economists are able to generalize about the objective of any economic agent (households): maximize utility. This is an important first working principle of the market-oriented economy. In an idealized capitalist market economy, consumers' well-being is a paramount consideration. What this means is that the effectiveness of an economy is judged by how well it satisfies the material needs of its citizens —the consumers. Therefore, given that resources are scarce, an effective economy is one which is capable of producing the maximum output from a given set of basic resources (labor, capital and natural resources). Of course, as discussed in Chapter 1, this is possible if, and only if, resources are fully employed and no misallocation of resources exists. In other words, if the economy is operating on its production possibility frontier, that automatically ensures efficiency. Thus, the second working principle of a market economy is that efficiency is the primary criterion, if not the sole criterion, to be used as a measure of institutional performance. The question then is, what conditions must a market system satisfy in order to be considered as an efficient institution for allocating resources? In other words, what are the conditions consistent with the ideal or perfect form of market structure? According to prevailing economic thought, a market has to satisfy the following broad conditions in order to be regarded as an efficient institutional mechanism for allocating resources:

1 Freedom of choice based on self-interest and rational behavior Buyers and sellers are well informed and exhibit "rational" behavior. "Rational" here refers to the notion that the behavior of a buyer or a seller is consistent with her or his pursuit of self-interest. It is further stipulated that these actors in the market are provided with an environment conducive to free expression of their choices. Note that as discussed in Chapter 1, choice is an inevitable by-product of resource scarcity.

2. Perfect information: Economic agents are assumed to be provided with full information regarding any market transactions. They are also assumed to have perfect foresight about future economic events.

3. Competition: For each item subjected to market transaction, the number of buyers and sellers is large. Thus, no one buyer or seller can single-handedly influence the terms of trade. In modern economic jargon, this means that both buyers and sellers are price-takers. This is assumed to be the case in both the product and the factor markets.

4. Mobility of resources: In a dynamic economy, change is the norm. Significant shifts in economic conditions could result from a combination of several factors, namely, changes in consumer preference, income, resource availability and technology. To accommodate changes of this nature in a timely fashion, resources must be readily transferable from one sector of the economy to another. This is possible only when barriers to entry and exit in an industry are absent (or minimal).

5. Ownership rights :All goods and services, as well as factors of production, have clearly defined ownership rights. This condition prevails when the following specific conditions are met: (a) the nature and characteristics of the resources under consideration are completely specified; (b) owners have title with exclusive rights to the resources they legally own; (c) ownership rights are transferable—that is, ownership rights are subject to market transactions at terms agreeable with the resource owner(s); and (d) ownership rights are enforceable (Randall 1987)—that is, property rights are protected by binding social rules and regulations.

When the above five conditions are met, an economy is said to be operating in a world of **perfectly competitive markets**. In such a setting, Adam Smith (the father of modern economics) declared over two centuries ago, the market system through its invisible hand will guide each individual to do not only what is in her or his own self-interest, but also that which is for the "good" of society at large. A profound statement indeed, which clearly depicts the most appealing features of the market economy in its ideal form. In the next two sections, this will be demonstrated systematically using demand and supply analysis.

A comprehensive understanding of the specific nature of the interrelationships between the human economy and the natural environment requires some basic knowledge of ecology.

Review and discussion questions

1 Carefully review the following economic concepts and make sure you have a clear understanding of them: factors of production, opportunity cost, increasing opportunity cost, efficiency, optimality, an economy, households, a firm, product and factor markets, intrinsic value.

2 State True or False and explain why.

(a) Resources are of economic concern only if they are scarce.

(b) There is no such thing as a free lunch. the absence of technological advance, Costa Rica cannot have more of both livestock production and ecosystem service unless it was operating inefficiently initially. (d) The postulate that resources are fungible renders the problem of scarcity manageable.

3 "Resources are culturally determined, a product of social choice, technology and the workings of the economic system" (Rees 1985:35). Do you agree or disagree with this assertion? Why?

4 In your opinion, what are some of the opportunity costs of clearing an extensive area of a topical rain forest? Do all your opportunity costs have immediately recognizable economic values? If your answer to this question is no, what does this say to you about measuring the value of a natural resource by its commercial value? Explain.

5 "Against the anthropocentric tendencies of most value theory, intrinsic values do exist apart from man's knowledge of them" (Cobb 1993:214).Comment.

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.3.3: AN INTERPRETATIVE ANALYSIS OF DEMAND, SUPPLY AND MARKET EQUILIBRIUM PRICE

For a given product (goods and services), the market demand depicts the price buyers are willing to pay in aggregate for a specified quantity provided in the market at a point in time, holding all other factors affecting demand constant. if the quantity of a given product available in the market is Q0, other things being equal, P0 is the maximum price consumers would be willing to pay. On the other hand, if what is available in the market is Q1, it follows that consumers would be willing to pay P1. In general, the price-quantity relationship shows that, other things being equal, quantity demanded is inversely related to price. In other words, the market demand for a product is negatively sloped. What is the significance of the "other things being equal" assumption? Why is the demand curve for a product negatively sloped? In the normal construction of the market demand for any product, certain variables are held constant. Some of the key variables include income, prices of related goods, the preference of consumers for the product under consideration, and the number of relevant consumers. A change in any one of these variables will be manifested by a shift in the entire demand curve, an market are provided with an environment conducive to free expression of their choices.

For example, normally, an increase in the average income of consumers will shift the demand curve outward from D0 to D1. This implies that with a rise in average income, for any given level of the product offered in the market consumers will be willing to pay a higher price. Hence, if what is offered in the market is Q0, with an increase in average income the price consumers are willing to pay increases from P0 to P1. The important lesson here is the recognition that market demand is a measure of consumers' willingness to pay, which depends on some key variables such as income, prices of related goods and consumer preference. The next question that we need to address is why it is that the consumers' willingness to pay declines when the quantity of a product available in the market increases.

3.4: EVALUATING THE PERFORMANCE OF A PERFECTLY COMPETITIVE MARKET ECONOMY

We have so far identified a market as an institution. The performance of an institution cannot solely be based on its daily operations. A valid judgment on the performance of an institution should be based on the enduring qualities of long-term outcomes. In this regard, the claim often made by mainstream economists is this: Provided that all the assumptions of the model of perfect competition discussed in Section 3.2 are satisfied (freedom of choice and enterprise; consumers and producers as fully informed price takers; mobility of resources; clearly defined ownership rights), in the long run the market system will tend to allocate resources efficiently. Furthermore, market prices will measure the true scarcity value of resources. To demonstrate these claims in a systematic manner, let us suppose that the long run equilibrium condition of a product produced and sold in a perfectly competitive industry. In this case, Pe and Qe represent the market equilibrium price and quantity, respectively. It is important to note that the long-run equilibrium price is that which prevails after the existence of above-normal profits has attracted new firms to enter the industry (or below-normal profits have forced some firms to exit). It is, in other words, where all firms in that particular industry are making just normal profits. Normal profit means that, in the long run, firms in a given industry cannot make a return from their investment above what they would have been able to earn if they had invested in some other industry with similar operating conditions and a similar risk environment. To see the “social” significance of this long-run equilibrium situation, let us separately analyze the economic conditions of the consumers and producers.

Consumers' surplus shows the same demand function . Thus, Pe and Qe represent the long-run market equilibrium price and output. Pm is the price where the quantity demanded is zero. Thus, it can be interpreted as the maximum price consumers are willing to pay for this product rather than go without it. By focusing on the demand alone, we will now be able to demonstrate the implication of the long-run market equilibrium for the consumers’ welfare. From our earlier discussion, we know that the demand curve depicts the maximum price consumers are willing to pay for a given quantity of the product provided in the market. For example, Pm is the maximum price consumers are willing to pay rather than go without the product. On the other hand, at the market equilibrium quantity, Qe, the consumers are willing to pay the price Pe. For quantities between 0 and Qe, consumers will be willing to pay prices higher than Pe and lower than Pm. Note that the prices consumers are willing to pay successively decline as the quantity of a product available in the market increases. This diminishing willingness to pay is, of course, consistent with the law of demand. To illustrate the above concept, let us assume, in a given market, that there are some eager consumers who would be willing to pay as much as $20 for a gallon of gasoline. If gasoline price in this market were more than $20, no one would buy any. If the price of gasoline were less than $20, then we can be sure that some amount of gasoline would be purchased. Suppose the actual market price is $1.50; those consumers who were willing to pay as much as $20 now essentially save $18.50 for every gallon of gasoline that they purchase. It is this kind of saving that is being conveyed by the concept of consumers’ surplus.

Looking at demand as a measure of willingness to pay also lends itself to the interpretation of price as the marginal private benefit to consumers. That is, a consumer whose sole interest is to maximize utility will not purchase an additional unit of a product unless the benefit derived from the incremental unit is at least equal to the market price. The fact that the price or marginal private benefit declines as the quantity of the product increases is also consistent with the law of diminishing marginal utility. If prices can be looked at as a measure of marginal private benefit, then, conceptually, we can compute the total private benefit by summing all the marginal benefits for a given range of the output demanded. For example, for the market equilibrium of output, Qe, the total consumers' benefit would be measured by the sum of all the prices starting from Pm all the way up to and including Pe. This is represented by the area of trapezoid OPmRQe. In an ideal (competitive) market, in the long run this area would tend to be maximized. The reasons for this are not difficult to see. Given that both consumers and producers are price-takers and resources are freely mobile, the long-run equilibrium condition ensures that firms are operating efficiently (minimizing their costs of production). In addition, due to the free mobility of resources, firms are not able to make an above-normal profit. If this situation prevails, then the market equilibrium price, Pe, represents the lowest price firms can charge in the long run. If Pe represents the lowest price, it follows that Qe is the largest output that could be forthcoming to the market. Thus, the trapezoid area represents the largest total consumers' benefit. This total consumers' benefit is composed of two parts. The first part represents what the consumers actually paid to acquire the market clearing output, Qe. The second segment represents the sum of all the prices above the equilibrium price that consumers would have been willing to pay. Since consumers did not actually pay higher prices for some units, but paid Pe for every unit up to Qe, the sum of these prices, represents consumers' surplus. In other words, consumers' surplus is the difference between the total willingness to pay and what consumers actually paid. What is significant here is that in the long run consumers' surplus is maximized. This is easy to demonstrate given that the long-run equilibrium price, Pe, represents the lowest feasible price for producers.

CHAPTER SUMMARY

The objectives of this chapter were twofold. The first aim was to clearly specify the institutional conditions under which individuals working in their self-interest will promote the welfare of the whole of society. The second was to show the various roles of prices and the extent to which product prices can be used as measures of resource scarcity.

• To address these issues fully and systematically, the following three key assumptions were made:

1 Markets are perfectly competitive.

2 The economy is evaluated on the basis of its long-term performance.

3 The criteria for evaluating market performance are based on the market's ability (a) to attain efficient allocation of resources so that, in the long run, the aggregate social surplus is maximized, and (b) to transmit accurate signals of resource scarcity.

• It was shown that, given the above assumptions, a market system uses price information to facilitate the production and exchange of goods and services. These prices are formed by the interaction of market demand (a measure of consumers' willingness to pay) and market supply (a measure of producers' willingness to sell).

• Furthermore, when one assumes the existence of clearly defined ownership rights, market demand and supply reflect marginal social benefit (MSB) and marginal social cost (MSC), respectively. Thus, the long-run equilibrium is attained when the following condition is satisfied: Pe=MSB=MSC, where Pe is the long-run equilibrium price. This condition has the following important implications:

1 The fact that MSB=MSC suggests that, in the long run, competitive markets allocate resources in such a way that the net social benefit (the sum of consumers' and producers' surplus) is maximized. This is because no reallocation can be made without adversely affecting the net social benefit. Thus, in the long run, competitive markets are Pareto efficient. 2 Market price is a measure of the value "society" attaches to a product. That is, Pe=MSB. 3 The market equilibrium price of a product, Pe, is a measure of the "social" cost of using basic resources (labor, capital, land, etc.) to produce the desired product. That is, Pe=MSC. 4 Market price, Pe, is a "true" measure of resource scarcity because there is no discrepancy between the social value of the product (what people are willing to pay) and the social opportunity cost of the resources used to produce this product. One important implication of this observation is that market intervention through subsidies or support prices would cause distortion of important social opportunity cost(s) and in so doing lead to a misallocation of resources.

• Finally, it was observed that a secular price trend of a final product (such as electricity) can be used as an indicator of emerging "general" resource scarcity—general in the sense that the opportunity cost of the resources (land, labor, capital) used to produce a particular product has been either increasing or decreasing over time. However, a trend in product price may not be reliable as an indicator of emerging scarcity of a specific resource. This is an important concern, especially in natural resource economics. To what extent a trend in product price can be used as an indicator of emerging natural resource scarcity depends on factor substitutions, factor shares, technology, and the general condition of factor markets.

Review and discussion questions

1 Briefly identify the following concepts: the invisible hand, perfectly competitive markets, willingness to pay, consumer and producer surplus, price-taker, diminishing marginal product, absolute and relative scarcity, clearly defined ownership rights, misallocation of resources, Pareto optimality, factor share. 2 State True, False or Uncertain and explain why.

(a) Decisions reached individually will be the best decision for an entire society. (b) Markets are meant to be efficient, not fair.

3 In a perfectly competitive market setting, relative price can be viewed as a measure of opportunity cost. For example, suppose the price of Good X is $ 10 and the price for Good Y is $5. The price of X relative to Y indicates that the opportunity cost of X is 2Y. Does this mean that (a) the physical availability of Y must be twice that of X, or (b) the production of a unit of Y uses only half of the resources needed to produce X? Explain.

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CHAPTER FOUR: FUNDAMENTALS OF THE ECONOMICS OF ENVIRONMENTAL RESOURCES

4.1. Introduction

Previous parts discussed the economics and ecological perspectives of natural resources and their implications for the economic and the natural world, respectively. In many respects, viewed separately and in abstract, the differences between these two perspectives may appear to be irreconcilable. However, pragmatic considerations require the recognition that both perspectives have relevance when the issue at hand deals with the coexistence of humanity with nature. It deals with the economics of using the environment for the disposal of waste products from human activities the economics of pollution. This is a relevant economic issue because the environment has a limited though not necessarily fixed capacity to self-degrade waste which is subject to the natural biological processes of decomposition. This means that the problem of environmental pollution cannot be adequately addressed without a sound understanding of the economics and ecological dimensions of the problem. This need for an integrative approach to ecology and economics should be apparent . In this respect, this chapter provides a first look at how ecological and economic concepts can be jointly used to help us understand and resolve resource problems of vital social concern. The discussions are limited to the fundamental elements of a subject commonly known as ªenvironmental economics.º The emphasis is on understanding the following two points: (a) the key ecological and technological factors that are essential in understanding the trade-off between increased economic activities and environmental degradation; and (b) the reasons why a system of resource allocation that is guided on the basis of individual self-interest (hence, private markets) fails to account for the social costs of environmental damage and what can be done to remedy this omission. Concepts like assimilative capacity of the environment, common property resources, public goods, externality, transaction costs, market failure and environmental taxes are discussed. Chapter 5 also briefly discusses the macroeconomic effects of environmental regulations measures

Although it may be objectionable to some, the conventional wisdom in environmental and resource economics is to view the natural environment as a commodity or an asset with a multitude of qualitative attributes (Tietenberg 1992). Let us consider a river flowing along a wooded area as an example. To avid anglers, this river is a valuable asset because it serves as a constant source of fish. To a group of nature lovers, the value of this river may be primarily spiritual. Moreover, for these individuals, the river may not be viewed in isolation from its surroundings. To yet another group, the river may serve as a dumping ground for industrial waste. This example shows that the environment is a multifaceted asset or commodity. It can be used as a spiritual object, aesthetic consumption goods, a source of renewable resources such as fish, and/or a dumping ground for waste. In this chapter the primary focus will be on the economic management of the natural environment (in the form of either water, air or landmass) in terms of its potential service to degrade or store waste. A "proper" management of the environment to this end requires the following two considerations. First, there should be a good understanding of the nature of the waste-absorptive capacity of the environment under consideration. Second, there should be a mechanism by which to identify the costs (degradation of environmental quality) and the benefits resulting from the use of the natural environment to an economic end (the production of more goods and services). In other words, the trade-off between economic goods and environmental quality or degradation needs to be carefully assessed, taking into consideration the opportunity costs for all alternative uses of the environmental asset in question. To address these issues thoroughly and systematically, in the next section an attempt is made, using a simple model, to explain the relationship between economic activities (production and consumption of goods and services) and the waste-absorptive capacity of the natural environment. The primary objective of this model is to identify certain key ecological and technological factors that are essential in understanding the tradeoff between increased economic activities and environmental degradation.

SUMMARY

• This chapter has dealt with concepts and principles fundamental to understanding standard environmental economics.

• It was postulated that the assimilative capacity of the environment (i.e., the ability of the natural environment to degrade waste arising from an economic activity) is in effect scarce, and is affected by a number of ecological and technological factors.

• It was observed that, for degradable pollutants such as most municipal wastes, a certain minimum amount of economic goods can be produced without causing damage to the natural environment. The exception to this is the emission of a highly toxic and persistent chemical compound such as DDT. In such a case, a zero level of pollution may be justified—like the ban on DDT in the United States.

• However, given that most economic activities extend beyond the ecological thresholds necessary to keep the integrity of the natural environment intact , trade-offs between increased economic activity and level of environmental quality become unavoidable.

• It was noted that the search for the "optimal" trade-off between economic and environmental goods requires full consideration of all the relevant social costs and benefits. Unfortunately, for environmental resources, this cannot be done through the normal market mechanism for the reasons outlined below:

1 Environmental resources, such as the atmosphere, all large bodies of water and public lands, are common property resources, and access to them has traditionally been open to all users. 2 Consequently, environmental resources tend to be prone to externalities—incidental costs imposed by a third party. 3 In the presence of externalities, economic pursuits on the basis of individual self-interest (hence, the private market) do not lead to what is best for society as a whole. This is because a freely operating private market has no automatic mechanism to account for external costs. Thus, scarce environmental resources are treated as though they are free goods. 4 When external costs are unaccounted for, the production of economic goods and services is in excess of what is socially optimal, and the quality of the environment is compromised.

Alternatively, the above problem could be viewed this way. In the presence of an externality, market prices fail to reflect "true" scarcity value. Price is a measure of "true" scarcity when the market equilibrium price, Pe, is equal to both marginal social cost and marginal social benefit (i.e., Pg=MSC=MSB). However, in the presence of an externality, the market equilibrium price, Pe, is equal to marginal private cost but not the marginal social cost ($Pe=MPC<MSC$). This is because the market simply ignores the external component of the social cost (MSC=MPC+ MEC). Thus, since $Pe<MSC$, market price fails to reflect "true" scarcity value. • Once this is understood, a possible solution to this type of externality problem is to find a mechanism which will account for external costs and correct the price distortion. • A Pigouvian tax—a tax on the

output of pollution-generating firms—is an example of such a mechanism. At the socially optimal level of output, $Ps=MSC=MPC+t^*$, where t^* is the optimal tax rate and a measure of marginal external cost. Thus, market prices again reflect "true" scarcity. However, finding the optimal tax rate is not an easy matter; and the Pigouvian approach to environmental regulation has several flaws.

• Finally, it was shown that regulating the market to take into account environmental externalities is accompanied by a decline in economic goods and an increase in price. Therefore, one often-raised concern is the macroeconomic effect of environmental regulations. In general, environmental regulations are suspected to have a negative effect on the economy for two reasons. First, they increase the private costs of firms. Second, they reduce the productivity of the economy because resources are diverted from the production of goods and services to investment in pollution control. Despite this claim, studies of the effects of environmental policies on macro variables such as GNP, inflation, productivity and unemployment have been inconclusive.

Review and discussion questions

1 Briefly identify the following concepts: persistent pollutants, ecological threshold, common property resources, transaction cost, joint consumption, externality, market failure, the "polluter-pays" principle, internalizing externality, government failure, the Porter hypothesis. 2 State True, False or Uncertain and explain why.

(a) "Everybody's property is nobody's property." (b) Waste emission should not exceed the renewable assimilative capacity of the environment. (c) While most taxes distort incentives, an environmental tax corrects a market distortion. (d) Environmental regulation creates more jobs than it destroys.

3 It makes no sense whatsoever to talk about the "optimal" trade-off between economic goods and environmental quality when this outcome requires a prior knowledge of a precise level of tax to be levied on polluters. Comment. 4 In some instances, consideration of "transaction costs" alone could make internalizing an externality (positive or negative) economically indefensible. Can you provide three concrete examples of this nature?

5 Due to concern about "global warming," imagine that the United States is considering doubling its federal tax rate on gasoline. The intent of this bold legislative measure is, of course, to drastically curtail the emissions of greenhouse gases, especially carbon dioxide.

(a) Do you think the measure will succeed? Why or why not?

(b) How would you evaluate this policy measure on the basis of "fairness?" That is, is the effect of the tax neutral with regard to different income groups? If not, what income group (s) do you think will end up paying most of the taxes? Explain.

(c) A member of the United States Congress arguing against the gasoline tax remarked, "It is stupid on our part to think that unilateral action by our country will remedy a global pollution problem." Another congressman countered this argument by saying, "We are the richest nation on the face of the earth. Furthermore, we emit substantially more greenhouse gases than any other nation in the world. It is, therefore, incumbent upon us to take a lead in this noble endeavor to save humanity." Are these two views reconcilable? Why, or why not?

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4.2. THE PERENNIAL DEBATES ON THE BIOPHYSICAL LIMITATIONS TO ECONOMIC GROWTH

a) Malthusian perspective

• This part deal with analyses of the Malthusian perspective on “general” resource scarcity and its implications for the long-term material well-being of humanity.

• This perspective has a long history and it starts with the premise that natural resources are finite and, therefore, will eventually limit the progress of the human economy.

• This conclusion is further reinforced by the observation that, historically, human population and per capita resource consumption have grown exponentially. The key feature of exponential growth is that it seems to start slowly and then continues fast. Malthusians, therefore, stress the danger of exponential growth (Ehrlich and Holdren 1993).

• Malthusians typically manifest their concerns in terms of the eventual depletion of some key, but conventionally identified, natural resource (such as oil, gas, arable land, uranium, etc.).

• Malthusians are generally skeptical about the ability of technology to circumvent biophysical limits for two reasons:

1. They believe that technological progress is subject to diminishing returns.

2. They are mindful of the long-run costs of technological cures. Some even take the position that malign technologies are the major culprit in the modern environmental crisis.

• In searching for solutions, Malthusians favor tightly regulated demand management—a reduction in the demand for resources. This includes population control and a reduction in per capita resource consumption.

• In general, Malthusians tend to emphasize population control as a key policy variable. They believe that if human society fails to address the population problem effectively, the future outlook is bleak.

• For Malthusians, concern for the well-being of future generations is paramount. This requires abandonment of our long-held "exponential-growth culture, a culture so heavily dependent upon the continuance of exponential growth for its stability that it is incapable of reckoning with problems of nongrowth" (Hubbert 1993:125).

b) **Neoclassical economic perspective**

• In this part we discuss the neoclassical economic perspective on "general" resource scarcity and its implications for the long-term material well-being of humanity Neoclassical economists do not reject outright the notion that natural resources are finite. However, unlike the Malthusians, they do not believe that this fact implies that economic growth is limited. Neoclassical economists uphold this position for five reasons:

1 .They believe that technology—by finding substitutes, through discovery of new resources, and by increasing the efficiency of resource utilization—has almost no bounds in ameliorating natural resource scarcity.

2. They differentiate between “general” and “specific” natural resource scarcity. To them, general or absolute scarcity (that is, the awareness that there is “only one Earth” and that it is a closed system with regard to its material needs) is tautological, therefore uninteresting. What is relevant is scarcity of specific resources, or relative scarcity.

3. However, relative scarcity does limit growth, due to the possibility of factor substitution.

4. In sharp contrast to the Malthusians, neoclassicists believe that economic growth, through increases in per capita income and improvements in technology, provides solutions to environmental and population problems.

5. Neoclassical economists believe in the effectiveness of the market system to provide signals of emerging resource scarcity in a timely fashion. Price distortions arising from externalities simply require a minor fine-tuning of the market.

• Given that societal resources are allocated by a smoothly functioning and forward-looking market, the key resource for continued human material progress is knowledge. It is through knowledge that human technological progress (a necessary ingredient for circumventing biophysical limits) will be sustained indefinitely.

• Thus, the best inheritance to leave to posterity is knowledge in the form of education (stored information about past discoveries) and physical capital.

• This is done without concern about the nature of the capital inherited by future generations, because for the neoclassical paradigm, human-made capital (roads, factories and so on) and natural capital (forest, coal deposits, wilderness, etc.) are substitutes. Much human progress, especially that of the past two centuries, has stemmed from the substitution of human-made for natural capital.

• According to the neoclassical growth paradigm, this process will continue into the future. Therefore, future humans’ material progress will be determined primarily by the pace of technological growth. Given the evidence of the past two centuries, the expectation is for a brighter future. Furthermore, this prognosis is independent of the fact that natural resources are finite.

Review and discussion questions

1 Briefly identify the following concepts: negative and positive checks to population growth, exponential growth, the Malthusian margin, the Malthusian notion of subsistence survival, real per capita output, technical progress, economies of scale

2. State True, False or Uncertain and explain why.

(a) The connection between population growth and environmental damage is undeniable. More people cause increasing damage to the environment. (b) It is inadequate to identify the "optimal" level of population solely in terms of its correspondence to the maximum real per capita output (such as L1 in Figure 6.1). (c) Economies of scale are neither a necessary nor a sufficient condition for technical progress to occur.

3. Malign technology, not population growth or affluence, has been primarily responsible for today's global population problems. Critically comment.

4. The isolated and sporadic instances of hunger that we continue to witness in parts of our contemporary world do not support the Malthusian theory. These events are caused not by population pressure but by poor global distribution of resources. Do you agree? Why, or why not?

5. Garrett Hardin (1993:94) wrote, "[even though] John Maynard Keynes had the highest opinion of his contributions to economics, Malthus continues to be bad-mouthed by many of today's sociologists and economists. The passion displayed by some of his detractors is grossly disproportionate to the magnitude of his errors. A conscientious listing of the explicit statements made by Malthus would, I am sure, show that far more than 95 percent of them are correct. But for any writer who becomes notorious for voicing unwelcome 'home truths' a correctness score

of 95 percent is not enough." In your opinion, is this a convincing and substantive defense of Malthus? Discuss.

6. Briefly identify the following concepts: absolute scarcity, extractive resources, real cost, the strong and weak hypotheses of increasing natural resource scarcity, the "inverted U" hypothesis, the environmental Kuznets curve, the theory of demographic transition.

7. State True, False or Uncertain and explain why.

(a) Since resources have substitutes, "nature imposes particular scarcities, not an inescapable
(b) (b) Rising per capita income will ultimately induce countries to clean up their environment. Thus, economic growth can be prescribed as the remedy to environmental problems.
(c) (c) Improved social and economic status for women is the key to controlling population growth.

8. "The major constraint upon the human capacity to enjoy unlimited minerals, energy, and other raw materials at acceptable price is knowledge. And the source of knowledge is the human mind. Ultimately, then, the key constraint is human imagination acting together with educated skills. This is why an increase in human beings, along with causing additional consumption of resources, constitutes a crucial addition to the stock of natural resources" (Simon 1996:408). Do you agree? Why, or why not?

9 .Do you see a parallel between the concept of Ricardian rent and real cost of extractive resources as defined by Barnett and Morse in the present chapter? Explain.

10. Studies of long-run scarcity of natural resources of the Barnett and Morse variety are primarily criticized for the following two reasons: (a) They fail to make explicit consideration of environmental quality concerns, (b) They fail to account for the substitution of high-quality energy resources for labor and capital that has been taking place in the extraction sectors. Are these valid criticisms? Explain.

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c) ECOLOGICAL ECONOMICS: NATURE AND SCOPE

This part discusses the ecological perspective on "general" resource scarcity and its implications for the long-run material well-being of humanity.

• In contrast to neoclassical economics, the ecological economic perspective seems to be rather cautious. In large part, this caution is a result of looking at biophysical limits from a broader context.

• Ecological economists do not view the human economy as being isolated from natural ecosystems. In fact, the human economy is regarded as nothing but a small (albeit important) subset of the natural ecosystem. Furthermore, since these two systems are considered to be interdependent, ecological economists focus on understanding the linkages and interactions between economic and ecological systems.

• From such a perspective, the scale of human activities (in terms of population size and aggregate consumption of resources) becomes an important issue. Furthermore, in ecological economics the consensus view seems to be that the scale of human development is already approaching the limits of the finite natural world—the full-world view. This has several implications. Among them are:

1. It is imperative that limits be put on the total resources used for either production and/or consumption purposes—stock maintenance.
2. "The essential measure of the success of the economy is not production and consumption at all, but the nature, extent, quality, and complexity of the total capital stock, including

the state of the human bodies and minds included in the system" (Boulding 1966:304). 3 As far as possible, the use of throughput should be minimized, which implies the production of goods and services that are long-lasting and easily recyclable. Technology could play a significant positive role in this regard.

• On the other hand, technology will not be able to circumvent fundamental energy, pollution and other natural resource constraints for two reasons: first, natural and human-made capital are complements; second, availability of natural resources will be a limiting factor to continued economic growth.

• Thus, according to the ecological economic perspective, it is imperative that human society make every effort to ensure that the scale of human activities is ecologically sustainable. This necessitates careful consideration of biophysical limits, and intergenerational equity. These concerns extend beyond humanity, to the future well-being of other species and the biosphere as a whole. • In many respects, one of the major contributions of ecological economics has been to shift the focus of the debates on natural resource scarcity from limits to economic growth to sustainable development.

Review and discussion questions

1. Briefly identify the following concepts: throughput, growthmania, the "cowboy" economy, the "spaceman" economy, intermediate means, intermediate ends, ultimate means, ultimate ends, the steady state economy, irreversibility, complementarity of factor of production, the precautionary principle, intergenerational equity.

2. State True, False, or Uncertain and explain why.

• Consideration of "ultimate ends" is beyond economics—which is not a moral science.

• In general, complementarity of factors of production implies the existence of limits to factor substitution possibilities.

• A steady-state economy is a theoretical model with no practical significance.

• An economy can "develop" without experiencing "growth."

3. It is argued that all transformations require energy; energy flow is unidirectional; and there is no substitute for energy. It therefore makes sense to use energy as a numeraire—a denominator by which the value of all resources is weighed. That is, energy is the ultimate resource. Critically comment.

4. Why is uncertainty an important consideration in ecological economics?

5. Nicholas Georgescu-Roegen labeled “steady-state” a “topical mirage” and pointed out its logical snags: “The crucial error consists in not seeing that…even a declining [growth] state which does not converge toward annihilation, cannot exist forever in a finite environment…. [Thus], contrary to what some advocates of the stationary state claim, this state does not occupy a privileged position vis-à-vis physical law.” Is this a fair criticism of the steady-state economy? Explain.

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CHAPTER FIVE: THE ECONOMY AND THE ENVIRONMENT IN RWANDA

The environmental impact of economic growth can be positive or negative and both can occur simultaneously, makingit difficult to assess the ultimate gains. There is the conundrum of economic growth, which allows greater investments in improving and protecting the environment, but increases consumption, waste and greenhouse gas emissions. The way forward is to "green" the economy, which will improve "human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP, 2011a).

5.1. Size of the economy and economic growth

Rwanda's Gross Domestic Product (GPD) in 2001 was about 1.8 trillion RWF at 2011 constant prices. The country's economy grew at an average growth rate of almost 7 per cent between 2001 and 2014. As a result, the size of the economy reached about 4.69 trillion RWF at 2005 constant prices, which is more than double the GDP in 2001.

GDP per capita at constant 2011 prices grew at an average annual rate of 4.92 per cent over the period 2001-14, rising from 207,000 RWF to 387,000 RWF over that time.

Although Rwanda enjoyed an encouraging growth in GDP per capita, the distribution of income is highly uneven. In 2011, income of the poorest 20 per cent of the population accounted for 5.16 per cent of the national income, while the income of the richest 20 per cent of the population accounted for 56.84 per cent of the national income. Structure of the economy by sector and expenditure.

The primary sector's share of GDP was 37 per cent in 2001 but declined to 33 per cent by 2013. Its average share of value added to total GDP over the period 2001-2013 was about 35.35 per cent. In other words, close to one-third of the country's economy depends mainly on agriculture, which itself primarily depends on the natural environment and ecosystem services.

The service or tertiary sector was the main contributor to the country's GDP over the period 2001-2014 and its share to GDP has been growing (Figure 12). From 2001 to 2005, the average share of value added to total GDP in the tertiary sector was about 49 per cent; from 2006 to 2013, it grew to 53 per cent. The value added in the secondary sector (manufacturing and non-manufacturing industries), contributed an average of about 13.2 per cent of Rwanda's GDP over the period 2001-2013.

5.2. Accounting for natural wealth

Gross Domestic Product (GDP), as illustrated above, only measures income as a proxy for economic performance and national wealth. It does not account for the ecosystem goods and services that underlie this income. Natural capital is a critical asset, especially for developing countries where it accounts for an average 36 per cent of total wealth (World Bank, 2015b). According to GDP measures of wealth, mineral exploitation, timber harvests and agricultural outputs increase GDP; on the other hand, these activities deplete the natural wealth of other ecosystem goods and services these resources provide, such as carbon sequestration, air and water filtration and biological diversity (World Bank, 2015b).

The link between the economy and ecosystem services is illustrated by the fact that nutrient depletion through soil erosion on Rwanda's agricultural lands is causing a decline in crop productivity. A recent ongoing study by the Economic Valuation of Options (Scenarios) working group of the Economics of Land Degradation Initiative — a global initiative for sustainable land management — focuses on the Economics of Agricultural Land Degradation in Africa (UNEP, 2015). Preliminary findings reveal that nutrient loss through erosion is causing a considerable loss in productivity of cereal crops in Rwanda. It was estimated that in the cropping seasons of 2010-2012, there had been a loss of about 11,300 tonnes of NPK nutrients per year from about 400,000 ha of land cultivated with cereal crops. The loss in cereal crops due to soil erosion-induced nutrient depletion was estimated at about 406,700 tonnes/year or 1.02 tonnes/ha/year (UNEP, 2015).

Thus, GDP is a misleading gauge of a country's economic performance and well–being and needs to be adjusted to account for resource depletion, pollution and declining ecosystem services (UNEP, 2011a). One way to include natural wealth in economic terms is through natural capital accounting.

5.3. Natural Capital Accounting

In 2012, the UN Statistical Commission adopted a System for Environmental and Economic Accounts (SEEA). This provides an internationally–agreed upon method to account for material natural resources like minerals, timber and fisheries (World Bank, 2015b). Rwanda recognizes that Natural Capital Accounting (NCA) can add value to the national development planning process by focusing attention on economically important natural resource sectors and providing consistent, reliable data to support economic assessments (WAVES, 2015a).

Rwanda has thus recently joined the Wealth Accounting and Valuation of Ecosystem Services (WAVES), a global partnership led by the World Bank that aims to mainstream natural capital in development planning and national economic accounting systems (WAVES, 2015b). Rwanda is committed to implementing Natural Capital Accounting and now has an NCA Steering Committee and a Technical Working Group. It has completed a scoping phase and approved sectoral priorities and a work plan for implementation. During

the first year, it will focus on land and water accounts (WAVES, 2015a).

Land and water accounts will contribute to assessing Rwanda's progress towards greening its agriculture sector because land availability and productivity and water supplies are potential constraints to agricultural growth, a key pillar of Rwanda's development agenda (WAVES, 2015a).

5.4. Green growth

The move towards promoting "green" growth, instead of economic growth for growth's sake, is an important development in the international community towards accounting for the environmental resources that underpin the economy and measuring well-being in more human terms. The Global Green Growth Institute (GGGI) defines green growth as "balanced economic growth that results in a broad based improvement in key aspects of social performance, such as poverty reduction, job creation and social inclusion, and environmental sustainability, such as mitigation of climate change, conservation of biodiversity and security of access to clean energy and water" (GGGI, n.d.).

In short, the Green Economy improves "human wellbeing and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP, 2011a). In its 2011 Green Economy Report, UNEP reports that compared to conducting "Business As Usual" or "BAU", investing in the green economy produces more growth and jobs and provides clean water and energy services to more people while also reducing greenhouse gas emissions (GHG) and improving the environment in many ways in the medium and long terms. The United Nations Conference on Sustainable Development (UNCSD) or the Rio+20 Summit in 2012 endorsed the green economy as an important mechanism for achieving sustainable development (Barr, 2013).

Rwanda is committed to greening its economy, as outlined in its Green Growth and Climate Resilience Strategy, the National Strategy for Climate Change and Low Carbon Development (RoR, 2011). It also participates in UNEP's Green Economy initiative. Indeed, UNEP has developed a set of Green Economy Indicators (GEI) to enable member nations to measure their progress in transitioning to a green economy (UNEP, 2014). Accordingly, Rwanda has recently developed a set of national indicators for sectors that are critical to transitioning to a green economy: agriculture, forestry, water, energy, mining and extractive industries, transport and sanitation and urban development, and will be using these to measure its progress in the future.

5.5. Rwanda's ranking on the Global Green Economy Index

The Global Green Economy Index (GGEI) is an innovative method to assess a country's progress towards greening its economy. The 2014 GGEI performance index is based on gauging performance in four main dimensions:

1. Leadership and Climate Change;

2. Efficiency Sectors;

3. Markets and Investment; and

4. Environment and Natural Capital. These dimensions are measured through 32 underlying indicators and datasets. The GGEI produces two rankings: one for actual performance, and another, the perception rank, which is the result of polling targeted respondents asking them to assess national green performance on the four main dimensions. According to the 2014 GGEI, Rwanda ranks 27th out of 60 countries in the performance rank but 48th in the perception ranking. Rwanda's performance score exceeds its perception one significantly – "signaling significant opportunities for improved green country branding and strategic communications" (Box 1) (Dual Citizen LLC, 2014).

Rwanda's performance in advancing the green economy greatly exceeds the general perception of its progress. The authors of the Global Green Economy Index suggest that Rwanda should improve the communication of its stellar progress in green growth to advance a global understanding of its green economy and associated market opportunities. They note that although Rwanda ranks as the top African performing nation on the Markets & Investment dimension, its corresponding perception rank is extremely low. The same is true for the Leadership and Climate Change and Efficiency Sectors. They suggest that with continued focus on green economic growth, Rwanda could quickly become the top performing African nation on the GGEI (Dual Citizen LLC, 2014).

5.6.Poverty and the environment

The poor, who for the most part live close to the land, are directly dependent on their immediate environments. Poor households in particular rely heavily on expenditure-saving, labour-intensive activities for their subsistence and survival, such as growing food, collecting water and fuel wood or grazing animals.

About 83 per cent of Rwandans live in rural areas and depend on the resources they can eke out of the land and waters for their sustenance and livelihoods. Agriculture accounts for almost half of aggregate household income, and much more for poor households (Hernandez, 2013). Any degradation of their land deepens their poverty.

Given the right circumstances, however, the poor are able to nurture their environments on a sustainable basis, improving material and social well-being for themselves and their offspring. Thus, rather than linear and causal, the poverty – environment connection is a very complex, multifaceted, multidimensional and context-specific one, varying over time and space (Koziell & Saunders, 2001).

UNIT 2: COSTS AND BENEFITS OF ENVIRONMENTAL POLICIES

CHAPTER 1: RESOURCE VALUE AND UTILISATION

1.1 Introduction

In most cases individuals refers to only economic benefits when looking at the value of environmental resources. There are some other values that are attached to environmental resources summing up to five. Sometimes these are referred to as five E‟s as explained below;

1.2. Ethical value referred to as intrinsic value

This is the value of resource unto itself, regardless of its value to humans. This justifies existence of mountain scenery, worm in the wastes etc. If these resources have a right of existing, then high intrinsic value should be ascribed to them. Intrinsic values are ecocentric or environmental oriented. The rest of the E‟s are referred to as extrinsic values. The extrinsic values are the ones which are external to resources own right to exist, refer instead to the resource‟s ability to provide something for human beings. Such values are anthropocentric (human centered). Extrinsic values are more utilitarian or practical, than intrinsic values and therefore tend to be more widely discussed in political and economic debates on resource management.

1.3. Esthetic value (Aesthetic value)

This is the value of resource in making the world more beautiful, more appealing to the senses and generally more pleasant. The value one place on a mountain hike in the cool morning air is an example. Some people place no value to this and would pay nothing for it while others find it indispensable.

1.4.Emotional values

This is the value resource beyond sensory enjoyment. Some people for example develop very strong emotional bonds to certain natural areas or certain animal or plant species. This is sometimes called sense of a „„place"". Many psychologists consider nature to be important for mental health, especially children.

1.5.Economic value

This is type of value involved with tangible products that can be bought or sold. For example food, timber, energy etc. Society needs to focus more on long term economic values, which actually provide more income over the long run. The value of resources for tourism, native fruits, or other sustainable products is ultimately much greater than the value of their destructive uses.

1.6.Environmental service values

This is the value of resources in providing intangible services that allow humans (and other life) to exist on earth. Plants help to purify air, produce oxygen and plant roots and soil microbes purify water. Some people put all the five values on all environmental resources. Others put different values on resources like beach etc. Logging, mining and other types of harvesting that destroy the resources are called direct values. Most environmental problems arise when the resources are appreciated for only their direct value. Placing only „„direct"" short term economic value on natural resources artificially „„discount"" their true value to society and to the future generations. Environmental service, emotional, esthetic and ethical values are referred to us indirect values, meaning that they are in ways that do not involve direct harvesting or other destruction of the resources. More sustainable uses of resources, such as extractive forestry and ecotourism, will be encouraged and rewarded. As long as only short term values are considered, overuse and exploitation will be encouraged and rewarded. Incumbent in the resource utilization is sustainability. Thus most often environmental natural resource managers tend to stress on sustainable utilization of resources. This is as crucial to natural resources as it ensures longevity and persistent quality for generations who depend on resource in question.

1.7**. Resource Utilization**

Resource utilization needs to be addressed thoroughly because even ubiquitous (omnipresent) resources may quickly go extinct if misused. Uncontrolled use of natural resource may result into wastage of the same resource and the population that depends on it may easily fall in scarcity of resources. Key issue that is worth to note and that needs consideration in resource utilization is increase in longevity of resource use. The resource should be used for the longest time possible without compromising its quality i.e sustainable resource use.

1.8. Sustainable Resource Utilization

Sustainable resource utilization means resource use process that bears within it elements of perpetual aspects of the same resources. Some impacts that emanate from resource misuse are permanent with far reaching fatal impacts. With sustainable resource utilization the resource use by the present generation should not deny the right for the future generation to use the same resources. Hence sustainable resource utilization means utilization of resources rationally on the basis that they can support the present and future generations. The major aim of sustainable resource utilization is to attain sustainable development in which resources are used in solving the current problems without jeopardizing the possibility for the future generation to exist. In other words sustainable utilization of resources is the utilization of resources while observing resource management and conservation principles for the resources to last longer. The basic resources of the world that are likely to subject the earth into crisis unless they are used with great care are water, air, forests, minerals, agricultural land, special ecosystems and tourism resources.

Below is a description of how some of these resources can be used to ensure longevity and maintain yield.

(i) Water resources

Water must be considered in terms of quality, quantity and accessibility. For instance lakes, rivers, swamps, underground waters are necessary to support population and economic development of the people. The critical shortage of water inhibits economic development and directly damage people as diseases may erupt. Major economic sectors like transport, agriculture and industries depend on water at one point for proper function. Sustainable utilization of water involves channeling and absorbing excess water, efficient distribution of the available water, avoiding disposing wastes in water bodies that interfere with water quality, avoid cultivation along river banks and at river sources. Water reservoirs should be constructed to tap rain water to avoid risk of shortage during dry period.

(ii**) Minerals like** iron ores Minerals like copper, tin, mica; diamond, gold etc. have greater contribution towards economic development hence these nonrenewable resources need to be managed properly. When managed properly mines will yield economic products for a long time. Governments and companies involved in mining activities should have proper environmental rehabilitation projects, like revetment of the soil, planting of trees, enacting laws and regulations to reinforce mining companies to rehabilitate land when mining activities ceases in a particular place.

(iii)Forests

Forests should be used with conservation mind because careless use of trees may lead to their disappearance. There should be proper reforestation programs to ensure that deforested areas are rehabilitated. Only mature trees should be harvested. Alternative sources of energy should be sought to relieve forests of the pressure pressed to it by both rural and urban population.

(iv) Land

When land is used especially in agriculture, care should be taken to maintain nutrients in it. When nutrient in the soil decrease, proper fertilization preferably by using organic fertilizers should be done. Cultivation in areas which are prone to soil erosion should be properly done by using contours. Proper agronomic practices should be adhered to in order to avoid land degradation in course of agricultural activities. Rotational cropping is one of good agricultural practices that ensure safety to agricultural land.

(v) Air

Air is the resource that is available everywhere on earth. Misuse of atmosphere by dumping in it undesirable gases, has led to major environmental problems facing the world today. The problems range from global warming, acid rain to depletion of ozone layer. There should be deliberate efforts to ensure discharge of harmful gases such as Chlorofluorocarbons (CFCs) into the atmosphere. Rational utilization of resources for economic purposes will ensure continuous use of the same resource for a long time. On the other hand a wasteful use of resources will result into ill-impacts which will come back to community and harm it, soon or later.

1.9. Resource Depletion

The pressure on the environment due to human activities has been greatly enhanced due to the accelerated use and depletion of natural resources. Given the finite nature of resources the ultimate aim is to achieve sustainable use of the natural capital. When the rates at which certain resources are used exceed their ability to renew (replenish) themselves these resources are at risk of exhaustion. This is simply termed resource depletion as it is further explained below.

Principally there two basic inputs from the environment, namely matter and energy

1.9.1. Depletion of Matter

Matter resources are depleted by being „„lost"" or dispersed. Ore deposits are usually concentrated deposits of minerals that are normally found in dilute form in the earth"s crust. When the minerals are mined and processed metals are obtained they can be used to make cars and other refined products. The atoms contained in the minerals may be dispersed i.e. wearing and tearing of the materials or lost to further human use when wastes are disposed in landfills and elsewhere, the urban ore of a landfill may later be mined for its metal contents. Similarly rapid soil erosion depletes the soil not because the nutrients and minerals in the soil are destroyed, but because the soil is dispersed, ultimately into the oceans. These are examples of nonrenewable matter; when dispersed, molecules of metals and soils will stay dispersed unless much energy and money is used to concentrate them. In terms of renewable matter resources, dispersion still occurs such as when houses are built out of timber relatively quickly. The renewable resources are Often biological resources that can be re-grown.

1.9.2 Depletion of Energy

Resources Energy has a one-way flow through society because it is transformed to unusable form

„„waste heat"" when used. Energy resources are therefore depleted when they are transformed this way. This is a key difference from some forms of „„lost"" matter, which could be recollected and reconcentrated if cheap energy is available. In contrast ones energy is transformed, it is lost forever; waste heat can never be reconcentrated. For example when coal or oil is burnt to release their chemical energy to drive engine that energy can never be reused. It is because of the one way flow of energy that always an alternative form environmental friendly energy which is ubiquitous is recommended and that is sun. This source of renewable energy could potentially keep the society running for many millions of years. Examples of sun"s energy include direct solar power, biomass, hydropower and wind power.

1.10. Bubble Pattern of Resource depletion

Unsustainable use of many resources exhibits a bubble pattern of depletion. The best known example is the so called Hubbert"s Bubble of oil depletion. King Hubbert predicted accurately the bubble patterns of oil depletion in the United States. The assumptions were made in 1950s and have proven to be strikingly accurate. U.S oil production peaked in 1970 and has been declining since the richest reserves are steadily depleted. The bubble pattern has two causes:

exponential exploitation and exponential depletion. Because both use and exhaustion are exponential, they tend to make mirror image. The exploitation, side of the bubble is exponential because resources are exploited very quickly once society discovers their utility. The underlying cause of this exponential use is the exponential growth of human populations and technology that uses the resources.

All resources on the earth are finite, limits to growth eventually occur, and demand exceeds supply. At this stage, society usually tends to intensify its efforts to obtain more of the resources through further exploration and increased technological applications. However these efforts soon usually encounter what is termed Law of Diminishing Return, in economics, meaning that increasing efforts to extract resource produce progressively smaller amounts/returns. This results into depletion side of the bubble. Production declines exponentially because the most easily extracted concentrations of the resource become exhausted. As supply of the resource decline, prices rise sometimes leading to unemployment and other unpleasant changes. Historically the society responds to the increase in resource prices by switching to another resource. England switched from wood to coal as energy, when forests were decimated and more recently to oil because it is cheaper. The series of bubbles shown in England has often been repeated elsewhere and with other resources as societies have tended to switch from one unsustainable resource to another. The only way to break this „„cycle of Unsustainable use"" is to switch to sustainable uses.

Study Questions

1. Enumerate and explain various values ascribed to different natural resources by human beings
2. Degradation of resources turns the resources in question noxious to individuals who previously depended on the resource. Using any resource of your choice support this contention
3. Most values attached on environment are human centered ignoring other components of environment. Discuss. 4. Explain the concept of bubble trend of resource depletion. 5. Why do resources get depleted? 6. Write an essay on sustainable resource utilization. Cite specific

resources and explain 7. Soil is ubiquitous and there to stay, yet it is placed into a nonrenewable resource group. Explain

CHAPTER TWO: ENVIRONMENTAL VALUATION

By environmental valuation, we mean estimating the economic values of natural resources and environmental assets, goods and services whereas environmental accounting connotes the process and act of recording the values of environmental assets, goods and services in an appropriate set of records/accounts and incorporating those values in the National Accounts. Environmental valuation and accounting can be useful for several purposes such as formulation and appraisal of natural resource development projects (for example, soil conservation, wastelands development and flood control), preparing green national accounts, that is, accounts that incorporate the benefits and costs of natural resources and environmental amenities and services, determining the trade-offs between economic development and quality of environment and the extent of financial liability of firms and households who degrade natural resources and pollute the environment.

2.1. Meaning and types of environmental values

 Use values, which are most commonly known, refer to the capacity of a good or service to satisfy our needs or preferences.

 total economic value : can be divided into two broad categories:

 instrumental or use value, and **intrinsic** or non-use (or passive use) value

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 Direct use values consist of consumptive uses such as timber harvesting and non-consumptive uses such as camping, hiking and bird watching. Indirect use values include environmental services such as maintenance of the hydrological system, climatic stabilization (e.g., carbon fixing) and soil stabilization.

The economic value of a natural resource or an environmental good can be expressed as follows:

 Total economic value (TEV) = use value (UV) + non-use value (NV)

 The UV may be further broken down into direct and indirect use values.

Use and non-use values of benefits from the environment

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 Intrinsic or non-use values, as the name suggests, are inherent in the good. That is, the satisfaction we derive from the good is not related to its consumption, Non-use or passive use values comprise existence value, bequest value and option value.

. **Existence value** arises from the benefit an individual derives from knowing that a resource exists or will continue to exist regardless of the fact that they have never seen or used the resource, or intend to see or use it in the future. A good example of the significance of non-use value is the international outcry over the whaling issue. There are many people who have never seen a whale or plan to see one, but are nevertheless witlings to pay significant sums of money to ensure that whales are not hunted to extinction.

 Bequest values arise from the benefits that individuals derive from knowing that a resource will be available for their children and children's children. Option value is a little more complex. Option value may be defined as the amount of money an individual is willing to pay, at the current time, to ensure that a resource is available in the future, should they decide to use it.

 To the extent that option value is the expected value of future use of the resource, it may also be classified as a use value.

2.2. Non-Market Valuation Methods

Non-market valuation methods can be broadly classified into two categories: **revealed preference** (RP) approaches and **stated** (or expressed) preference (SP) approaches (Figure 7.2). Revealed preference approaches make use of individuals' behavior in actual or simulated markets to infer the value of an environmental good or service. For example, the value of a wilderness area may be inferred by expenditures that recreationists incur to travel to the area.

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 The value of, say, noise pollution may be inferred by analyzing the value of residential property near an airport. These methods are also referred to as indirect or surrogate market approaches.

Examples of RP methods include:

– Travel Cost Method (TCM)

– Hedonic Pricing Method (HPM)

– Cost (or Expenditure) Methods, and

– Benefit Transfer Methods

Classification of non-market valuation methods

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 Stated preference methods attempt to elicit environmental values directly from respondents using survey techniques, hence the alternative name of 'direct approach', As will be explained below, these methods are flexible and can be applied to a wider range of environmental goods and services than RP methods. Furthermore, SP methods can be used to estimate total economic value (Lee, use and non-use values), whereas RP methods can be used to estimate only use values. Stated Preference methods do have some drawbacks and these are discussed below:

Stated Preference methods

SP methods can be further classified into two categories: contingent valuation method (CVM), and choice experiments. In this section we first consider the CVM and then go on to discuss choice experiments.

The contingent valuation method

The CVM uses interview techniques to ask individuals to place values on environmental goods or services. The term 'contingent' in CVM suggests that it is contingent on simulating a hypothetical market for the good in question. The most common approach in the CVM is to ask individuals the maximum amount of money they are willing to pay to use or preserve the given good or service. Alternatively, the respondents could be asked the maximum amount of money they are willing to accept in compensation (WTA: willingness to accept) to forgo the given environmental good or service.

Typical steps in a CVM procedure are as follows:

1. Set up the hypothetical market;
2. Obtain the bids;
3. Estimate mean WTP and/or WTA; and
4. Estimate bid curves

Setting up the hypothetical market

The first step is to establish a reason for a good or service where there is no current payment. Suppose there is a government proposal to mine, say, a wilderness area. Assuming few people actually visit the area, the analyst would describe the area and the impacts of the proposed project on the environment. Pictorial aids could also be used in setting up this hypothetical market (not applicable to a telephone interview).

Obtaining the bids

The second step is to decide on a suitable 'bid vehicle'. This is the method by which the WTP or WTA bids would be elicited. Possible bid vehicles could include income taxes, property taxes, utility bills, entry fees, and payments into a trust fund.

Methods used to obtain the bids include face-to-face interviews, telephone interviews or postal surveys. A face-to-face interview allows more scope in presenting the hypothetical market and clarifying respondent concerns. However, it is the most expensive method because interviewers have to be paid.

The telephone interview and postal survey offer less flexibility, in declining order

Methods of obtaining bids include the following:

Bidding games: respondents are offered progressively higher bids until they reach their maximum WTP.

Payment card a range of values is provided on a card and the respondent is requested to choose one.

Open-ended questions: respondents are asked to report their maximum WTP.

Close ended questions:

For Close ended questions, there are at least three variants:

(i)**Dichotomous choice (referendum):** a single amount is offered and respondents are asked to provide a 'Yes' or 'No' answer, also referred to as the 'take it or leave it' or approach;

(ii) Double-bounded referendum: respondents who answer 'no' to the first amount are offered a lower amount, and those who answer 'yes' are offered a higher amount; and

(iii) Trichotomous choice: respondents are offered three choices to the payment-'yes', 'no' and 'indifferent'.

Estimating mean WTP and/or WTA: For the first three bids elicitation approaches the mean and median WTP can be found from the individual bids. Mean and median bids for the close ended referendum bids are more difficult to obtain. Analytical methods such as probit, logit and random utility models can be used to obtain estimates.

Estimating the bid (demand) curves

Bid (or demand) curves could be estimated at this stage to validate the WTP results and to estimate aggregate WTP. The bid curve is estimated by regressing WTP against relevant socioeconomic variables, and checking to see whether the signs conform to theory. For example, the following demand function could be estimated:

$WTP_i=f(A_i,E_i,Y_i,M_i)$: Where A is age; E is educational level; Y is income level and M is a variable for membership of an environmental organization. Based on economic theory, we would expect Y to be positively related to WTP.

The total value of the good or service can be estimated by multiplying the mean WTP by the number of households (if the sampling unit used was the household).

Choice experiments

Choice experiment approaches include conjoint analysis and choice modeling (CM). Conjoint analysis is further divided into contingent ranking, contingent rating and paired comparison.

Conjoint analysis

A major difference between CVM and conjoint analysis is that in the former respondents are required to evaluate only one or sometimes two alternatives. On the other hand, the latter requires them to evaluate several alternatives separately. In contingent rating, respondents are requested to rate their preferences for several alternatives on, say, a ten-point scale. They are presented with a set of attributes associated with each alternative. The respondents' ratings are then regressed against the attributes. The marginal rate of substitution between a given attribute and its price provides an estimate of the 'value' of the attribute.

. This is referred to as the 'part- worth' of the attribute. Summing all the part-worths provides an estimate of a respondent's WTP for an aggregate change in the environmental good or service. In contingent ranking, respondents are required to rank all the alternatives from least preferred to most preferred. The analysis of contingent ranking data is similar to that of contingent rating. The rankings can be converted to a ratings scale and analyzed with multiple regression techniques, or other estimation methods such as logit or probit analysis can be used.

Choice modeling

In this approach, respondents are presented with a series of alternatives, with each containing three or more resource use options. Usually, each alternative is defined by a number of attributes. For example, in a CM study of preserving a wilderness area the attributes could be the following: numbers of rare species present; ease of access to the area, size of area and cost to households. These attributes would then be varied across the various alternatives. The respondents are then required to choose their most preferred alternative.

Estimates of respondents' WTP are obtained by estimating a multinomial logit model.

Revealed preference methods

Revealed Preference methods include the travel cost method, the hedonic price method, market value or cost methods and the benefit transfer method.

Travel cost method (TCM)

The basic assumption underlying the method is that the costs an individual incurs in visiting a recreational site reflect the person's valuation of that site. By asking visitors questions relating to where they have travelled from and the costs they have incurred, and relating this information to the number of visits they make per annum, a demand curve can be generated for the recreational site under question.

This curve will be downward sloping in the sense that travel cost will be inversely related to number of visits . That is, those living near the site will make more visits per annum compared to those living far away.

. The information requested in a travel cost survey include the following: travel costs (petrol, food, and other travel-related expenses), income, alternative sites and personal motivations. Entrance fees to recreation sites are often non-existent or nominal. The demand curve relating travel costs (a proxy for the price of recreation) to number of visits can be used to estimate the total recreation value of the given site. Average travel cost per visit is multiplied by the total number of visits to the site to obtain the total annual recreational value of the site.

The hedonic price method

The hedonic price method (HPM) derives values for an environmental good or service by using information from the market price of close substitutes. It is based on Lancaster's consumption theory which assumes that a good or service provides a bundle of characteristics or attributes (Lancaster, 1966). Suppose the government wishes to value the disutility generated by aircraft noise in a given location. It could do this by analyzing variations in house prices as one move away from the flight path of aircraft.

In practice : the analyst specifies a mathematical function where the price of a house is determined by various attributes. For example: Price of house = f(number of rooms, access to amenities, income of tenant, environmental quality)

2.3. Market value methods

Market value approaches make use of observed market prices for environmental goods and services. Based on our classification of TEV above, it can be seen that this approach can only be used to value environmental goods and services that have established markets. These are commodities which have:

- **Direct uses**: e.g., plantation timber, commercial fisheries, tourism;
- **Some indirect uses**: e.g., the value of water from protected watersheds; and
- **Some option values**: e.g., gene research, forest conservation.

. Market value methods attempt to find a link between a proposed environmental change and the market value of the corresponding goods and services. A common approach is to use changes in productivity of the good or service. For example, the direct impacts of an environmental change on human health can be estimated as a change in income. The assumption here is that sickness reduces one's ability to earn income.

The advantages of the market value method are:

(1) It is relatively simple and straightforward; (2) It relies on actual market values; and (3) It has some relation to measured output.

The disadvantages are:

(1) It is limited in the types of values that it can capture;

(2) It can be difficult to define the physical flows over time;

(3) In some cases, the links between the environmental change and the market good or service may not be obvious.

Market cost method

In general, market-cost methods measure the cost of achieving a particular objective. Examples include restoring certain environmental services and avoiding land degradation. These methods focus on the cost of prevention or rectifying environmental damage and the cost of replacing environmental services. Most often, these costs are estimated from market prices, including the costs of labor and materials used in the particular activity.

There are a number of variations of the market cost method. These include the following: (1) change in cost; (2) replacement cost; and (3) defensive expenditures.

Change in cost method:

Suppose a proposed project may change the cost of a good or service. If the project causes a decrease in the good or service, this can be interpreted as a gain in benefits, that is, a cost saving. On the other hand if the project results in an increase in costs, this may be taken to be a loss of benefits. Take the example of a project that involves the construction of a water supply system. In this case a major benefit is the cost savings to households from not having to buy water from water vendors or transport water over long distances.

Replacement cost method: assumes that the value of an existing good or service is the cost of replacing it. For example, if a storm damages roads, buildings and transmission lines then an estimate of the damage done is the cost of replacing these structures. However, in this case, the replacement cost must be considered as the minimum value of the benefits derived from these goods. This is because we need to add on the consumer surplus that people derive from utilizing the good or service. A variation of replacement cost is mitigation cost. Mitigation cost is an estimate of the cost of restoring a damaged environmental good to its former condition. This approach could be useful where the damage is minor. Obviously, it is of limited use where the damage is either irreversible or total restoration is impossible.

Defensive-expenditure method: in this approach the net benefit of a particular project intervention is the amount of money people are willing to spend to either mitigate or avoid the impacts. A good example is a community which does not have potable water. In this case, the benefits of introducing a water treatment plant include the amount of money people spend to boil or treat their water for cooking or drinking purposes,

Limitation of market and cost methods

The market and cost methods are easy to apply and can provide useful measures of net benefits. People can easily understand the use of monetary units. However, a major limitation is that they do not measure benefits that are determined from the interaction between the demand for and supply of environmental goods. As such, they only capture a portion of total benefits (e.g., they exclude non-use benefits). Where there is a high degree of non-market benefits or costs, market values may provide only minimum estimates of opportunity costs or foregone benefits.

Benefit transfer method

It involves 'transferring' values that have been estimated for a similar good or service from another location to the current location. The approach is useful because surveys are expensive and, in addition to money, there could be a time constraint.

CHAPTER THREE: **THE ECONOMICS OF ENVIRONMENTAL RESOURCES: PUBLIC POLICIES AND COST BENEFIT ESTIMATIONS OF ENVIRONMENTAL DAMAGE**

3.1. THE ECONOMIC THEORY OF POLLUTION CONTROL

INTRODUCTION

In the previous parts an attempt was made to address the issue of environmental quality by looking at the trade-off society has to make between economic goods and improved environmental quality. In addition to merely recognizing the existence of this trade-off, in the same chapter an attempt was made to formally establish the necessary condition for attaining the level of output (economic goods) that would be consistent with the socially optimal level of environmental quality. This is an indirect approach, because the volume of waste emitted, which ultimately determines the quality of the environment, is presumed to be managed through output adjustment. This would pose no problem if there existed a stable and predictable relationship between waste emission and output, and if changes in market conditions did not have an independent effect on output. However, these are technical and economic considerations that can hardly be taken for granted. For these reasons, this chapter will discuss an alternative approach to the management of environmental quality by looking directly at the nature of waste disposal costs. Viewed this way, the economic problem will be to determine the volume of that is consistent with the socially optimal level of environmental quality; that is, the optimal level of pollution. This approach, as will be seen shortly, provides a good many helpful new insights as well as a thorough evaluation of all the economic, technological and ecological factors that are considered significant in assessing pollution prevention (abatement) and pollution damage costs.

3.2. MINIMIZATION OF WASTE DISPOSAL COSTS

As discussed , two principles, the first and second laws of thermodynamics, inform us that pollution is an inevitable by-product of any economic activity. Furthermore, as also discussed , a certain minimum amount of economic activity can be pursued without causing damage to the natural environment. This is because the natural environment has the capacity, albeit a limited capacity, to degrade waste, although for persistent pollutants (such as DDT, mercury, radioactive waste and so on) the assimilative capacity of the environment may be, if not zero, quite insignificant. Clearly, then, economic consideration of waste (pollution) becomes relevant when the amount of waste disposed exceeds the assimilative capacity of the environment. When this critical threshold is exceeded, what becomes immediately apparent is the trade-off between environmental quality and pollution. That is, further pollution beyond this threshold could occur only at the cost of reduced environmental quality. In other words, pollution occurs at a cost. This is, then, the rationale for pollution control strategy or environmental management. From a purely economic perspective, the management of environmental quality or pollution control is easily understood if the problem is viewed as minimizing total waste disposal costs. Broadly identified, waste disposal costs originate from two distinct sources. The first component is pollution control (abatement) cost: the cost which arises from society's cleanup effort to control pollution using some kind of technology. The second element is the pollution damage cost, which results from damage caused by untreated waste discharged into the environment. Thus Total waste disposal cost=Total pollution control (abatement) cost +total pollution damage cost. Hence, the economic problem of interest is to minimize the total disposal cost, with full recognition of the implied trade-off between its two components: control and damage costs. This is because, from an economic viewpoint, any amount of investment (expenditure) on pollution control technology will make sense if, and only if, society is compensated by the benefits to be realized from the avoidance of environmental damage, resulting directly from this specific investment. A good understanding of this economic logic requires, first of all, a clear and in-depth understanding of the nature of these two types of waste disposal costs, to which we now turn.

3.2.1 Pollution control (abatement) costs

The primary objective of this chapter was to derive the condition for an "optimal" level of pollution. This was done by closely examining the trade-offs between two categories of costs associated with pollution: pollution control and damage costs.

• "Pollution control costs" refers to all the direct or explicit monetary expenditures by society to reduce current levels of pollution; for example, expenditure on sewage treatment facilities.

• Pollution damage costs denote the total monetary value of the damage from discharges of untreated waste into the environment. Pollution damage costs are difficult to assess since they entail assigning monetary values to damage to plants and animals and their habitats; aesthetic impairments; rapid deterioration to physical infrastructure and assets; and various harmful effects on human health and mortality.

• Furthermore, it was noted that pollution damage costs are externalities.

• A trade-off exists between pollution control and damage costs. The more spent on pollution control, the lower will be the damage costs, and vice versa.

• In view of these trade-offs, it would be beneficial to spend an additional dollar on pollution control only if the incremental benefit arising from the damage avoided by the additional cleanup (waste control) exceeded one dollar. It can then be generalized from this that it would pay to increase expenditure on pollution control provided at the margin the control cost is less than the damage cost; that is, $MCC<MDC$.

It follows, then, that the optimal level of pollution (waste disposal) is attained when at the margin there is no difference between control and damage costs; that is, $MCC=MDC$. When this condition is met, the total waste disposal cost (the sum of the total control and damage costs) is minimized.

• Further analysis of the nature of the two categories of costs of pollution revealed the following:

1. The marginal pollution control cost increases with an increase in pollution cleanup activities. This is because, incrementally, a higher level of environmental quality requires investments in technologies that are increasingly costly.
2. The marginal pollution damage cost is an increasing function of pollution emission. This could be explained by the ecological principle that pollution reduces the capacity of a natural ecosystem to withstand further pollution.
3. The marginal damage cost can be interpreted as depicting society's willingness to pay for pollution cleanup, and hence, the demand for environmental quality.

   • Changes in preference for environmental quality and/or pollution control technology are exogenous factors that affect the optimal level of pollution. A clear understanding of this issue offers insights relevant to pollution control policies.

   • Another important issue addressed in this chapter is the possible divergence between economic and ecological optima. Three specific cases were examined to illustrate the significance of this issue:

   1. It was observed that since the economic problem is stated as finding the cheapest way to dispose of a predetermined level of waste, in searching for the economic optimum the emphasis has been on pollution cleanup rather than pollution prevention.
   2. Inconsistency between the economic and the ecological optimum may arise when the pollution under consideration is likely to impose environmental damage that is irreversible in the long term.
   3. Because damage costs are anthropocentrically determined, there is no assurance that the economic optimum level of pollution will adequately protect the well-being of other forms of life and the ecosystem as a whole.

Review and discussion questions

1. Briefly identify the following concepts: pollution control cost, pollution damage cost, persistent pollutants, eutrophication, pollution prevention.

2. State True, False or Uncertain and explain why. Answer these questions using a graph of marginal damage and control cost curves.

(a) Improvement in pollution control technology reduces pollution while at the same time allowing society to realize savings in its expenditure for waste control. A "win-win" situation, indeed!

(b) An increase in the living standard of a nation (as measured by an increase in per capita income) invariably leads to an increased demand for environmental quality and consequently to a reduction in environmental deterioration.

(c) The real pollution problem is a consequence of population.

3. Fundamentally, the economics of pollution control deals with the proper accounting of the trade-off between control and damage costs. Explain the general nature of the trade-off. Be specific.

4. Examine the following two statements. Are they equivalent?

(a) Pollution damage costs are externalities.

(b) Not all aspects of pollution damage costs can be evaluated in monetary terms.

5. Evaluate the relative merit of each of the following environmental management strategies. Identify a real-world case(s) under which one of these strategies is more appropriate than the others.

(a) Pollution should be "prevented" at the source whenever feasible.

(b) Pollution should be "controlled" up to a point where the total social cost for disposing it is minimized.

(c) Pollution should be controlled to prevent major long-term and irreversible ecological impacts.

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CHAPTER FOUR: THE ECONOMICS OF ENVIRONMENTAL REGULATIONS

Regulating the Environment through Judicial Procedures

After reading this chapter you will be familiar with the following:

• the economic rationale for environmental regulations;

• general criteria used for evaluating a specific environmental policy instrument;

• deterring environmental abuse through liability laws;

• the Coasian theorem and its implications for environmental regulations;

• emission standards as a policy tool for regulating environment pollution;

• the United States Environmental Protection Agency (EPA) and its legal mandates inetting emission standards.

The tragedy of the commons as a food basket is averted by private property, or something formally like it. But the air and waters surrounding us cannot readily be fenced, and so the tragedy of the commons as a cesspool must be prevented by different means, by coercive laws or taxing devices that make it cheaper for the polluter to treat his pollutants than to discharge them untreated. (Hardin l968:1245)

4.1.INTRODUCTION

In Chapter 3 the focus was on developing a theoretical framework that would direct us to the conditions under which a socially optimal level of environmental quality could be attained. One of the major revelations in that chapter was that environmental resources are externality-ridden. For this reason, the socially optimal level of environmental quality cannot be achieved through the unbridled operation of private markets. What this suggests is, as discussed earlier, a clear case of market failure and, consequently, a justification for public intervention. However, as will be evident, public intervention is not both a necessary and sufficient condition for attaining the optimal allocation of environmental resources. Sufficiency requires that we attain the optimal environmental quality through means (policy instruments) that are cost-effective—that involve the least cost. Hence, on practical grounds, resolving environmental problems requires more than a mere recognition of market failure or the necessity of public intervention to correct an externality. With this important caveat in mind, in this chapter we evaluate three legal approaches for regulating the environment, namely liability laws, property rights or Coasian methods, and emission standards. The unifying theme of these three approaches is their focus on the legal system to deter abuse of the environment. In the case of liability laws, the court would set monetary fines on the basis of the perceived damage to the environment. The Coasian method uses the legal system to assign and enforce property rights. Emission standards are set and enforced through legally mandated laws. Each of these policy instruments is evaluated on the basis of the following specific criteria: efficiency, compliance (transaction) cost, fairness, ecological effects, and moral and ethical considerations.

4.2. ENVIRONMENTAL REGULATION THROUGH LIABILITY LAWS

In many countries, including the United States, liability laws are used as a way of resolving conflicts arising from environmental damage. The main idea behind this type of statutory enactment is to make polluters liable for the damage they cause (Starrett and Zeckhauser 1992). More specifically, polluters are the defendants and those who are affected by pollution, the pollutees, are the plaintiffs. Thus, since polluters are subject to lawsuits and monetary payments if they are found guilty (see Exhibit 11.1), it is in their best interest to pay special attention to the way they use the ambient environment as a medium for waste disposal. In this sense, liability laws can be used as a means of internalizing environmental externalities. The question then is how effective is the use of liability laws in internalizing environmental externalities? We can address this question using as a hypothetical example the environmental dispute between two firms, a paper mill and a fish hatchery.

SUMMARY

This part discussed three alternative policy approaches used to internalize environmental externalities: liability laws, Coasian methods and emission standards. The unifying feature of these approaches is their direct dependence on the legal system to resolve environmental litigation.

• Liability law is one of the earliest methods used to deter abuses of the environment. This approach uses statutory enactment that is specifically intended to make polluters liable for the damage they cause. If found liable, polluters are ordered to pay to the plaintiff (in this case the pollutees) financial compensation in direct proportion to the damage they have inflicted.

• The principal advantages of liability laws are the following:

1. They are effective in deterring environmental nuisance (such as littering).
2. They have moral appeal since they are based on the polluter-pays principle.

The main disadvantages of liability laws are:

1. There is a high transaction cost when the number of parties involved is large.
2. They are "unfair" if the individual damaged does not have the resources to bring a lawsuit.

4.3. **The property rights or Coasian approach** is conceptualized on the fundamental premise that the root cause of environmental externalities is the lack of clearly defined ownership rights. The legal system is then used to assign enforceable ownership rights.

Furthermore, the Coase theorem affirms that the final outcome of an environmental dispute (in terms of pollution reduction) is independent of the decision made regarding the assignment of the property rights to a specific party: the polluter or pollutee.

The principal advantages of the property rights approach are:

1. It minimizes the role of regulators to a mere assignment of enforceable property rights.
2. It encourages the resolution of environmental disputes through private negotiations. In other words, it advocates a decentralized approach to pollution control.

The primary disadvantages of the property rights approach are:

1. The transaction costs are high when the parties involved in the negotiation process are large in number.
2. It appears to be indifferent to the polluter-pays principle.
3. It has the potential to affect the income distribution of the parties involved in the negotiation. In this respect, the final outcome may be judged to be "unfair."

4.4.**Emission standards** represent a form of command-and-control environmental regulations. The basic idea involves restricting polluters to a certain predetermined amount of effluent discharge. Exceeding this limit subjects polluters to legal prosecution resulting in monetary fines and/or imprisonment.

The main advantages of emission standards are:

1. Generally, less information is needed to introduce regulations. As a standard represents a government fiat, it is simple and direct to apply.
2. They are effective in curbing or controlling harmful pollution, such as DDT.
3. They are morally appealing and politically popular since the act of polluting is declared a "public bad."
4. They appeal to "rent-seeking" behavior of existing firms.
5. They are favored by environmental groups because standards are generally aimed at achieving a predetermined policy target.

The primary disadvantages of emission standards are:

1. They are highly interventionist.
2. They do not generate revenue.
3. They may require the establishment of a large bureaucracy to administer programs.
4. They are generally not cost-effective.
5. They do not provide firms with sufficient incentive to invest in new pollution control technology.
6. There is a strong tendency for regulatory capture: cooperation between the regulators and polluters in ways that provide unfair advantages to established firms.

Review and discussion questions

1 Briefly explain the following concepts: liability laws, the polluter-pays principle, the Coase theorem, transaction cost, cost-effective.

2 State True, False or Uncertain and explain why.

(a) Whether one likes it or not, the abuse of the environment cannot be effectively deterred without some degree of regulation of the free market. Thus, public intervention is both a necessary and a sufficient condition for internalizing environmental externalities.

(b) The air pollution problem can be solved by simply specifying or assigning exclusive rights to air.

(c) Environmental advocacy groups generally favor command-and-control approaches because these unambiguously convey the notion that pollution is bad and as such ought to be declared illegal.

3. Despite the appealing logic of the Coase theorem, private actors on their own often fail to resolve an externality problem because of transaction costs. Comment on this statement using two specific examples.

4. The core problem of a command-and-control approach to environmental policy is its inherent bias or tendency to standard-setting practice that is uniformly applicable to all situations. For example, the ambient-air quality standards in the United States are basically national. This may have serious efficiency and ecological implications because regional differences in terms of the factors affecting damage and control cost relationships are not effectively captured. EvaluateWould considerations of transaction costs have a bearing to your response to this question? Why, or why not?

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4.5.EFFLUENT CHARGES

An effluent charge is a tax or a financial penalty imposed on polluters by government authorities. The charge is specified on the basis of dollars or cents per unit of effluent emitted into an ambient environment. For example, a firm may be required to pay an effluent charge of $0.30 per unit of waste material it is discharging into a lake. Note that structurally, effluent charge is just a variation of Pigouvian taxes. For that matter, the only difference between these two policy tools is that a Pigouvian tax is assessed on a unit of goods or services whereas an effluent tax is charged on a unit of waste emitted. As public policy instruments, effluent charges have a long history and have been used to resolve a wide variety of environmental problems. For example, in recent years, to address the concern of global warming, several prominent scholars have been proposing a global carbon tax (Pearce 1991). As will be evident from the discussions to follow, the major appeals of an effluent charge are:

(a) It is less interventionist than emission standards and operates purely on the premise of financial incentive or disincentive, not on a command-and-control principle,

(b) It can be relatively easy to administer,

(c) It provides firms with incentives to reduce their pollution through improved technological means. How does the effluent charge approach work? This question is addressed by a situation where a firm is discharging waste into a particular environmental medium (air, water or land). This firm is required to pay an effluent tax in the amount of tk, or $20 per unit of waste discharged. We are also provided with the MCC curve of this firm. Given this information, it is fairly easy to draw the conclusion that a private firm interested in minimizing its cost would discharge 150 units of waste. Note that this means that the firm will control 250 units of waste (400–150) using its facility to clean the waste. This is cost-minimizing because at 150 units, the usual equimarginal condition is attained. More specifically, the marginal control cost is equal to the predetermined effluent tax; MCC=tk=$20. When this condition is met, the firm has no incentive to reduce its waste discharge to less than 150 units. To see this, suppose the firm decided to reduce its emission to 100 units. At this level of emission, the MCC= $30>tk=$20. Thus, paying the tax to discharge the waste would be cheaper to the firm than using its facility to clean the waste. A similar argument can be presented if the firm decides to increase its waste discharge to a level exceeding 150 units. However, in this case it would be cheaper for the firm to clean the waste using its waste-processing facilities than pay the tax; that is, MCC<tk. Simply stated, when a profit-maximizing firm is confronted with an effluent charge, it would be in its best interests to treat its waste whenever the cost of treating an additional unit of waste was less than the effluent tax (i.e., tk >MCC). The firm would cease its effort to control waste when no gain could be realized from any additional activity of this nature (i.e., tk=MCC). At this stage, it is important to note the following two points. First, without the effluent charge, this firm would have had no incentive to employ its own resources for the purpose of cleaning up waste. In other words, in Figure 12.1, since the service of the environment is considered a free good, this firm would have emitted a total of 400 units of effluent into the environment. This implies that an effluent charge reduces pollution because it makes the firm recognize that pollution costs the firm money—in this specific case, $20 per unit of effluent. This shows how an externality is internalized by means of an effluent charge. Second , when the effluent charge is set at tk, the total expenditure by the firm to control.

SUMMARY

This chapter discussed two alternative policy approaches that can be used to correct environmental externalities: effluent charges and transferable emission permits. The common feature of these two policy instruments is that they both deploy market incentives to influence the behavior of polluters. Effluent charges and transferable emission permits are alternative forms of market-based environmental policy instruments.

• Effluent charges represent a tax per unit of waste emitted. Ideally, a tax of this nature reflects the imputed value (on a per unit basis) of the services of an environment as repository for untreated waste. Thus, the idea of the tax is to account for external costs; effluent charge is used to correct price distortion. • The principal

Advantages of the effluent charges are:

1. They are relatively easy to administer.
2. They are generally cost-effective.
3. They generate revenues while correcting price distortions—the double-dividend feature of effluent charges.
4. They provide firms with incentives to invest in pollution control technology.

The main disadvantages of the effluent charges are:

1. Monitoring and enforcement costs are high.
2. They could have a disproportionate effect on income distribution.
3. They do not condemn the act of polluting on purely moral grounds. It is okay to pollute, provided one pays for it.
4. Firms are philosophically against taxes of any form, especially when they are perceived to cause increased prices and an uncertain business environment. 5 Environmental organizations generally oppose effluent charges for both practical and philosophical reasons. Pollution taxes are “licenses to pollute.” Taxes are generally difficult to tighten once implemented.

• The transferable emission permits approach to pollution control requires, first and foremost, the creation of artificial markets for pollution rights. A pollution right represents a permit that consists of a unit of a specific pollutant. The role of the regulator is limited to setting the total number of permits and the mechanism(s) by which these permits are distributed among polluters. Once they receive their initial allocation, polluters are allowed to freely exchange permits on the basis of market-established prices.

Primary advantages of transferable emission permits are:

1. They are least interventionist.
2. They are cost-effective, especially when the number of parties involved in the exchange of permits is large.
3. They provide observable market prices for environmental services.
4. They can be applied to a wide range of environmental problems.

The principal disadvantages of transferable emission permits are:

1. The mechanisms used to distribute permits among potential users could have significant equity implications.
2. The idea of permits to pollute conveys, to some, a reprehensible moral and ethical value.
3. Their applicability is questionable for pollution problems with an international scope.
4. They are ineffective when there are not enough participants to make the market function.
5. Permits can be accumulated by firms for the purpose of deterring entrants or by environmental groups for the purpose of attaining the groups' environmental objectives.

Preliminary empirical evidence indicates that the United States sulfur dioxide emissions trading program has performed successfully. Targeted emissions reduction have been achieved and exceeded, and at costs significantly less than what they would have been in the absence of the trading provisions. • This success would not necessarily apply in cases of international pollution. For example, could an emissions trading program be effective in cutting carbon dioxide emissions intended to reduce the risk of global warming? It will most likely be less effective than the United States' experiment in sulfur dioxide emissions reduction programs because of high enforcement and monitoring costs of a pollution problem with a global dimension.

Review and discussion questions

1. Briefly describe the following concepts: effluent charges, transferable pollution permits, the grandfathering principle, the Clean Air Act amendment of 1990, the bubbles, offsets and emissions banking policies.
2. State True, False or Uncertain and explain why.

(a) To say that an effluent charge is cost-effective does not necessarily mean that it is optimal. This is because cost-effectiveness does not account for damage costs.

(b) The remarkable feature of tradable permits is that they work best when the parties involved in the trade are large in numbers.

(c) Pollution taxes and tradable permits are "licenses to pollute."

(d) Effluent charges and permits provide unfair competitive advantages to existing firms.

3. Some economists argue that a policy instrument to control pollution (such as effluent charges and transferable pollution permits) should not be dismissed on the basis of "fairness" alone. The issue of fairness can always be addressed separately through income redistribution. For example, the tax revenue from effluent charges can be used to compensate the losses of the damaged parties. Critically evaluate.

4. As you have read in this chapter, since the mid-1980s the Environmental Protection Agency (EPA) in the United States has seemingly come to rely increasingly on transferable emission permits.

(a) In general, do you support this fundamental change in policy from the traditional "command-and-control" regulations to market-based trading of pollution allowances? Why, or why not?

(b) Why do you think the rest of the world is rather slow or not enthusiastic in adopting this type of pollution control policy? Speculate.

5. Environmental organizations have opposed market-based pollution control policies out of a fear that permit level and tax rates, once implemented, would be more

difficult to tighten over time than command-and-control standards. Is this fear justifiable? Why, or why not?

6. Which of the environmental policy options discussed in this and previous chapters would you recommend if a hypothetical society were facing the following environmental problems? In each case, briefly explain the justification(s) for your choice.

(a) a widespread problem with campground littering;

(b) pollution of an estuary from irrigation runoffs;

(c) air pollution of a major metropolitan area;

(d) the emission of a toxic waste;

(e) damage of lakes, streams, forests and soil resulting from acid rain;

(f) a threat to human health due to stratospheric ozone depletion;

(g) the gradual extinction of endangered species.

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