Natural resource economies – definition, subject matter and scope

Natural resource economics deals with the supply, demand and allocation of the earth natural resource. Main objective of natural resource economics is to better understand the role of natural resources in the economy in order to develop more sustainable methods of managing those resources to ensure their availability to future generations. Resource economists study interactions between economic and natural systems, with the goal of developing a sustainable and efficient economy. It is a multi - disciplinary field of academic research.

Natural resource management

Natural resource management refers to the management of natural resource such as land, water, soil, plants and animals with a particular focus on how management affects the quality of life for both present and future generations. Natural resource management deals brings together land use planning, water management, biodiversity conservation and the future sustainability of industries like agriculture, mining, fishing, etc.

Environmental and Ecological Economics

The insights into sustainability provided by mainstream economics are taken much further by environmental and ecological economists. The main areas of contribution include the following:

- A classification of sustainability views according to assumptions about the conservation of natural resources
- Extending the analysis of externalities to provide a basis for designing anti-pollution policies and deciding on the resources it is desirable to devote to avoiding pollution
- A range of methodologies for evaluating the services provided by environmental assets and social capital to extend the inclusiveness of Cost Benefit Analysis.
- Models for projecting the pricing and depletion of finite resources.
- Assessments of the implications of various access regimes governing the harvesting of renewable resources

There is considerable overlap in the subject matter of ecological and environmental economics. The key difference is one of orientation.

Environmental economics tends to embrace the Neo-classical paradigm as an analysis of the economic system and seeks to incorporate environmental assets and services.

Ecological economics gives priority to the health of complex interrelated ecological systems and consider how economic behaviour can be modified to that end.

Natural resources classification and characteristics:

Natural resources are often classified into renewable and non-renewable resources.

Renewable resources: Renewable resources are generally living resources (fish, coffee, and forests, for example), which can restock (renew).

Non- renewable natural resources: Non-living renewable natural resources include soil, as well as water, wind, tides and solar radiation, etc

Resources can also be classified on the basis of their origin i.e. biotic and abiotic.

Biotic resources: Biotic resources are derived from animals and plants (i.e-the living world). Biotic is a living component of a community; for example organisms, such as plants and animals.

Abiotic resources: Abiotic resources are derived from the non-living world e.g. land, water, and air. Mineral and power resources are also abiotic resources some are derived from nature. In biology and ecology, **abiotic components** are non-living chemical and physical factors in the environment which affect ecosystems.

Natural resources:

Water resource: Water resources are usually renewable resources which naturally recharge. Overexploitation occurs if a water resource is extracted at a rate that exceeds the recharge rate, that is, at a rate that exceeds the practical sustained yield.

Forest resources: Forest is overexploited when they are logged at a rate faster than reforestation takes place. Reforestation competes with other land uses such as food production, livestock grazing, and living space for further economic growth.

Deforestation

Deforestation is the removal of a forest or stand of trees where the land is thereafter converted to a non-forest use. Examples of deforestation include conversion of forestland to farms, ranches, or urban use. The term deforestation is often misused to describe any activity where all trees in an area are removed. However in temperate climates, the removal of all trees in an area—in conformance with sustainable forestry practices—is correctly described as regeneration harvest. In temperate climates, natural regeneration of forest stands often will not occur in the absence of disturbance, whether natural or anthropogenic. Furthermore, biodiversity after regeneration harvest often mimics that found after natural disturbance, including biodiversity loss after naturally occurring rainforest destruction.

Resources characteristics: Resources have three main characteristics namely

1) Utility,

2) Limited availability,

3) Potential for depletion or consumption.

In economics, **utility** is a measure of satisfaction, referring to the total satisfaction received by a consumer from consuming a good or service

Scarcity

Scarcity is the fundamental economic problem of having humans who have unlimited wants and needs in a world of limited resources. It states that society has insufficient productive resources to fulfill all human wants and needs.

Resource depletion

Resource depletion is an economic term referring to the exhaustion of raw materials within a region. Resource depletion is most commonly used in reference to farming, fishing, mining, and fossil fuels.

Causes of resource depletion

- Over-consumption/excessive or unnecessary use of resources
- Non-equitable distribution of resources
- Overpopulation
- Slash and burn agricultural practices, currently occurring in many developing countries
- Technological and industrial development
- Erosion
- Irrigation
- Mining for oil and minerals
- Aquifer depletion
- Forestry
- Pollution or contamination of resources

Natural resources are also categorized based on the stage of development:

Potential Resources are known to exist and may be used in the future. For example, petroleum may exist in many parts of India and Kuwait that have sedimentary rocks, but until the time it is actually drilled out and put into use, it remains a potential resource.

Actual resources are those that have been surveyed, their quantity and quality determined, and are being used in present times. For example, petroleum and natural gas is actively being obtained from the Mumbai High Fields. That part of the actual resource that can be developed profitably with available technology is called a **reserve resource**, while that part that cannot be developed profitably because of lack of technology is called a **stock resource**.

Management of renewable and non-renewable resources

A **natural resource** may exist as a separate entity such as fresh water, and air, as well as a living organism such as a fish, or it may exist in an alternate form which must be processed to obtain the resource such as metal ores, oil, and most forms of energy

Renewable resource

Renewable resource is a natural resource which can replenish with the passage of time, either through biological reproduction or other naturally recurring processes. Renewable resources are a part of Earth's natural environment and the largest components of its ecosphere. A positive life cycle assessment is a key indicator of a resource's sustainability. Renewable resources may be the source of power for renewable energy. Sustainable harvesting of renewable resources (i.e., maintaining a positive renewal rate) can reduce air pollution, soil contamination, habitat destruction and land degradation.

Non-renewable resource

Non-renewable resource is also known as a finite resource and is a resource that does not renew itself at a sufficient rate for sustainable economic extraction in meaningful human time-frames. An example is carbon-based, organically-derived fuel. The original organic material, with the aid of heat and pressure, becomes a fuel such as oil or gas. Fossil fuels (such as coal, petroleum, and natural gas), and certain aquifers are all non-renewable resources. David Ricardo in his early works analysed the pricing of exhaustible resources, where he argued that the price of a mineral resource should increase over time. He argued that the spot price is always determined by the mine with the highest cost of extraction, and mine owners with lower extraction costs benefit from a differential rent.

Carrying capacity

Use of natural resource services is compared with defined bio-physical limits for the supply of such services.

Economic Approaches to Resource Management

In **economics approaches** to resource management, the common denominator is typically some form of measurement that can be related to individual welfare. Economics provides a comprehensive framework for analysing most aspects of natural resource and environmental issues. Optimal extraction and use of non-renewable resources, in particular as analysed by the Hotelling's rule. Economic indicators of sustainability derived from the weak sustainability view that the total amount of capital must be maintained. The basic Hotelling Rule is based on a number of simplifying assumptions. The total stock of resources is assumed to be known and of equal quality, and all the market players are assumed to have full knowledge. The concept of management of non-renewable resources is mainly concerned with how a resource stock should be used optimally and not concerned with sustainability.

Major issues in use of natural resources – productivity, equity &sustainability

Sustainability:

The word sustainability is derived from the Latin sustinere (tenere, to hold; sus, up). The most widely quoted definition of sustainability and sustainable development, that of the Brundtland Commission of the United Nations on March 20, 1987: "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Environmental, social and economic demands - the "three pillars" of sustainability.

The word sustainability is applied not only to human sustainability on earth, but too many situations and contexts over many scales of space and time, from small local ones to the global balance of production and consumption. Sustainability is the capacity to endure.

In ecology, sustainability describes how biological systems remain diverse and productive over time, a necessary precondition for human well-being. Long-lived and healthy wetlands and forests are examples of sustainable biological systems.

Sustainability farming: It is the system that in which NRS are managed so that the potential yield and stock of NRS do not decline over time

Principles and concepts

The philosophical and analytic framework of sustainability draws on and connects with many different disciplines and fields. In recent years an area that has come to be called sustainability science has emerged. Sustainability science is not yet an autonomous field or discipline of its own, and has tended to be problem-driven and oriented towards guiding decision-making.

Scale and context

Sustainability is studied and managed over many scales (levels or frames of reference) of time and space and in many contexts of environmental, social and economic organization.

Consumption — population, technology, resources

The total environmental impact of a community or of humankind as a whole depends both on population and impact per person, which in turn depends in complex ways on what resources are being used, whether or not those resources are renewable and the scale of the human activity relative to the carrying capacity of the ecosystems involved.

To express human impact mathematically called as I PAT formula. This formulation attempts to explain human consumption in terms of three components: population numbers, levels of consumption and impact per unit of resource use, which is termed technology used.

The equation is expressed:

$$I = P \times A \times T$$

Where: I = Environmental impact,
P = Population,
A = Affluence,
T = Technology

Measurement

Sustainability measurement is a term that denotes the measurements used as the quantitative basis for the informed management of sustainability. The metrics used for the measurement of sustainability (involving the sustainability of environmental, social and economic domains are evolving: they include indicators, benchmarks, audits, sustainability standards and certification systems.

Resource productivity:

Resource productivity is the quantity of good or service (outcome) that is obtained through the expenditure of unit resource. This can be expressed in monetary terms as the monetary yield per unit resource.

Resource productivity and resource intensity are key concepts used in sustainability measurement. The sustainability objective is to maximize resource productivity while minimizing resource intensity

List of environmental issues

- Climate change
- Conservation
- Energy Environmental degradation
- Environmental health
- Intensive farming
- Land degradation —
- Soil
- Land use
- Overpopulation
- Ozone depletion
- Pollution
  - Water pollution
  - Air pollution
- Reservoirs Resource depletion

Equity and issues in equity of natural resources

Equity derives from a concept of social justice. It represents a belief that there are some things which people should have, that there are basic needs that should be fulfilled, and that policy should be directed with impartiality, fairness and justice towards these ends .Equity means that there should be a minimum level of income and environmental quality below which nobody falls.

Intra-generational equity

Equity can also be applied across communities and nations within one generation. The reason that intra-generational equity is a key principle of sustainable development is that inequities are a cause of environmental degradation. Poverty deprives people of the choice about whether or not to be environmentally sound in their activities.

Equity issues, key parameters and indicators:

Key parameters and indicators

First, the majority of people would be deprived in terms of low welfare level despite their hard work (equity failure),

Second, unfair access to public infrastructure, facilities and services could occur (equity failure). i.e . Failure to guarantee intra- and inter-generational equity would cause deep inequality and un sustainability

Third, natural resources may be so exploited that threaten their sustainability of use.

Fourth, negative externalities of economic activities could create serious threat to the environment

Equity issues:

Nine Equity Issues are

1. Income and employment system
2. Access to facilities and services
3. Access to natural resources
4. Fairness in competition
5. Natural resource exploitation

6. Negative externalities
7. Non-production function
8. Compensation to worse-off people
9. Sustainability reinvestment

Discount rate

Discounted cash flow (DCF) analysis is a method of valuing a project, or asset using the concepts of the time value of money. All future cash flows are estimated and discounted to give their present values (PVs). The discount rate reflects two things:

1. The time value of money
2. A risk premium .

Discrete cash flows

Discounted present value is expressed as:

$$DPV = \frac{FV}{(1+i)^n} = FV(1-d)^n$$

where

DPV is the discounted present value of the future cash flow (*FV*), or *FV* adjusted for the delay in receipt;

i is the interest rate, which reflects the cost of tying up capital.

d is the discount rate which is *i*/(1+*i*), i.e. the interest rate expressed as a deduction at the beginning of the year instead of an addition at the end of the year; and *n* is the time in years before the future cash flow occurs.

Continuous cash flows

For continuous cash flows, the summation in the above formula is replaced by an integration:

$$DPV = \int_0^T FV(t)\, e^{-\lambda t} dt\,,$$

where *FV*(*t*) is now the *rate* of cash flow, and λ = log(1+*i*).

Discounting

In order to compare costs and benefits at different points in time, we use the technique of discounting, in order to calculate present discounted value. The formula for present discounted value is given by

$$PV = \frac{X}{(1+R)^t}$$

where PV = present value

X = value to be received or paid in the future

t = number of years until the receipt or payment

R = "discount rate"

Why discount?

- opportunity cost of capital
- productivity of capital
- time preference in consumption
- impatience
- future generations may be better off.

Opportunity cost.

When markets do not exist

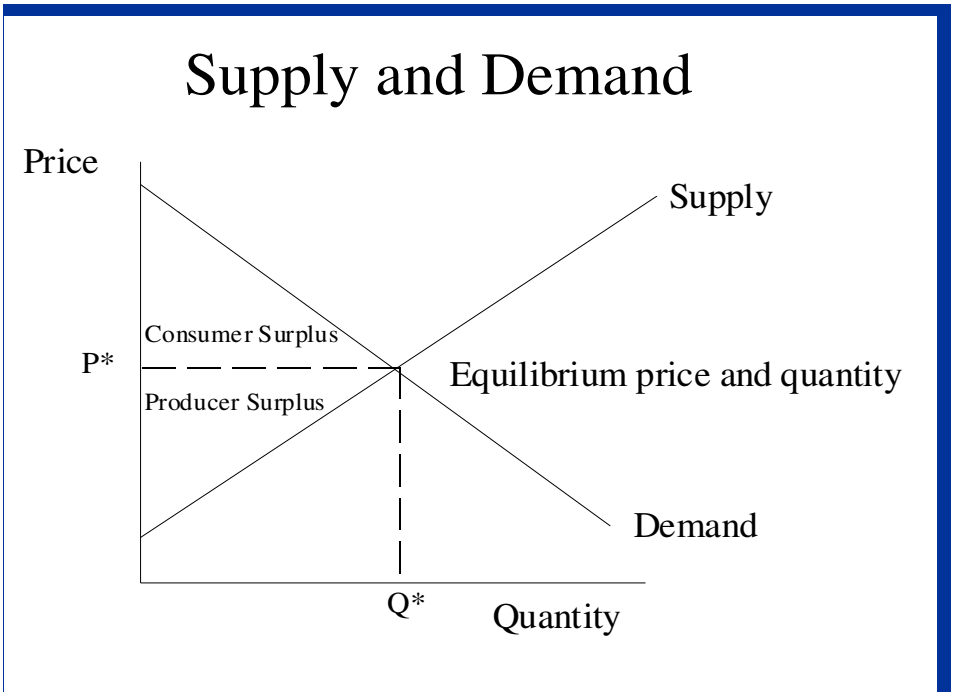
- Environmental goods and services often are not traded in markets, e.g., clean air.

Types of Economic Analysis

- Cost-benefit analysis
  - Identify and quantifying project impacts
  - Monetization

  - Damage assessment
- Economic impact analysis
- Cost-effectiveness analysis

Supply and Demand



Social rate of discount It is use estimating rate of discount for the following factors

1) Determining the depletion rate of non-renewable resources.
2) Determining the optimal rate of saving for nations.
3) Calculating social opportunity cost of public funds utilised in a multitude of purposes.
4) Calculating cost-benefit analysis.

Calculation

The SDR can be calculated by

$$(1/(1+r)^t)$$

where r equals the SDR and t equals time. For benefits or costs that have no end it is just

$$(1/r)$$

A higher SDR makes it less likely a social project will be funded. A higher SDR implies greater risks to the assumption that the benefits of the project will be reaped.

Differences between private and social discount rate

There are a number of qualitative differences between social and private discount rates and evaluation of projects associated with them. The governance of social project funding is different naturally, because estimating the benefits of social projects requires making ethically subtle choices about the benefits to others.

II - The Social time preference rate

Another school of economists believes that the correct rate of discount for public projects is the social time preference rate, STPR, which is also called the consumption rate of interest (CRI). The rationale for this argument is quite simple; the purpose behind investment decisions is to increase future consumption, which involves a sacrifice on present consumption. Therefore, what we need to do is ascertain the net consumption stream of an investment project and then use the CRI.

Market efficiency, externalities and types

Market efficiency

Efficiency of the market is measured as output- input ratio. It should be greater than one.

E = O/I

Types of market efficiency

Allocative efficiency :

This is a type of efficiency in which economy/producers produce only that type of goods and services which are more desirable in the society and also in high demand. According to the formula the point of allocative efficiency is a point where price is equal to Marginal cost (P=MC).

Pareto efficiency, or **Pareto optimality**:

It is a concept in economics. The term is named after Vilfredo Pareto, an Italian economist who used the concept in his studies of economic efficiency and income distribution. Given an initial allocation of goods among a set of individuals, a change to a different allocation that makes at least one individual better off without making any other individual worse off is called a Pareto improvement.

Productive efficiency (also **technical efficiency**):

Occurs when the economy is utilizing all of its resources efficiently, producing most output from least input. The concept is illustrated on a production possibility frontier (PPF). In long-run equilibrium for perfectly competitive markets, the average (total) cost curve i.e. where MC = A(T)C.

Productive efficiency:

Productive efficiency requires that all firms operate using best-practice technological and managerial processes. By improving these processes, an economy

or business can extend its production possibility frontier outward and increase efficiency further.

Economic efficiency:

Economic efficiency occurs at the level of output at which the marginal social benefits (MSB) equal the marginal social costs (MSC). MSB = MSC

Market efficiency levels

1. **Weak-form efficiency:** Prices of the securities instantly and fully reflect all information of the past prices. This means future price movements cannot be predicted by using past prices.

2. **Semi-strong efficiency:** Asset prices fully reflect all of the publicly available information. Therefore, only investors with additional inside information could have advantage on the market.

3. **Strong-form efficiency:** Asset prices fully reflect all of the public and inside information available. Therefore, no one can have advantage on the market in predicting prices since there is no data that would

Market failure:

Market failure is a concept within economic theory wherein the allocation of goods and services by a free market is not efficient. That is, there exists another conceivable outcome where a market participant may be made better-off without making someone else

Market power, Monopoly, Monopsony, Oligopoly, and Oligopsony

The inefficiency in the market lead to imperfect competition and causes market failure. Agents in a market can gain market power, allowing them to block other mutually beneficial gains from trades from occurring. This can lead to inefficiency due to imperfect competition, which can take many different forms, such as monopolies, cartels, or monopolistic competition, if the agent does not implement perfect price discrimination. In a monopoly, the market equilibrium will no longer be Pareto optimal.

The monopoly will use its market power to restrict output below the quantity at which the marginal social benefit is equal to the marginal social cost of the last unit produced, so as to keep prices and profits high.

Public goods

Some markets can fail due to the nature of certain goods, or the nature of their exchange. For instance, goods can display the attributes of public goods or common-pool resources, while markets may have significant transaction costs or informational asymmetry. In general, all of these situations can produce inefficiency, and a resulting market failure. This can cause underinvestment, such as where a researcher cannot capture enough of the benefits from success to make the research effort worthwhile.

Property right as right of control

This is the underlying cause of market failure. A market is an institution in which individuals or firms exchange not just commodities, but the rights to use them in particular ways for particular amounts of time. Markets are institutions which organize the exchange of control of commodities, where the nature of the control is defined by the property rights attached to the commodities. This falls into two generalized rights – excludability and transferability.

Excludability:

Deals with the ability of agents to control who uses their commodity, and for how long – and the related costs associated with doing so.

Transferability:

It reflects the right of agents to transfer the rights of use from one agent to another, for instance by selling or leasing a commodity, and the costs associated with doing so. If a given system of rights does not fully guarantee these at minimal (or no) cost, then the resulting distribution can be inefficient.

Externalities:

The allocation of resources to productive uses results from consumers and producers making decisions with the aim of maximizing satisfaction and profits, respectively. Private costs and benefits are taken into account in deciding purchases and organizing production. Social costs and benefits include the costs and benefits of consumer and producer but also costs borne by those who are not participating in that particular market. These are known as external costs and benefits or externalities.

External costs and benefits can arise through both consumption and production. From a sustainable development perspective, external costs are most significant and arguably account for the failure of individuals, communities and nations to follow a sustainable path.

Externalities types:

Negative Externalities: When economic agents not directly involved, negative externalities can exist, such as pollution.

Positive Externalities: Positive externalities in production means that social cost is less than private cost, and more of the good should be produced than will occur in a free market.

Efficient market: A market is said to be efficient if marginal price and marginal cost are equal. If not then a market is failure.

External costs

The shows the negative effects of a externality. i e pollution of industry.

External benefits

This shows the positive or beneficial effects of a externality. For example, the industry supplying smallpox vaccinations is assumed to be selling in a competitive market.

Market failure - externalities

Common resources

Externalities are third party effects arising from production and consumption of goods and services for which no appropriate compensation is paid. One of the major problems facing the environment is that **common resources** such as fish stocks and grazing land are not privately owned – commonly owned resources may lack the protection of property rights and are susceptible to over-exploitation because the marginal cost of extracting the resource for a private agent is close to zero.

When there are **environmental externalities**, the private equilibrium price and quantity determined by the interaction of market supply and demand is not the same as the social equilibrium which includes all internal and external costs.

In a **free market**, a producer will have little direct incentive to control pollution because it is external – i.e. the profit-maximising supplier considers only his/her own private costs and benefits.

Externalities and Market Failure

When there is a harmful production externality, the production of a good imposes external costs. The marginal social costs exceed marginal private costs by the amount of the external costs. When choosing how much to produce, firms are only concerned with their own costs, the marginal private costs (MPC). The market supply curve is the MPC curve.

Policies for Externalities

- Regulation
- Taxes/subsidies
- Pollution permits

Market imperfections and natural resources

Definition*:* Imperfect competition is a competitive market situation where there are many sellers, but they are selling heterogeneous (dissimilar) goods as opposed to the perfect competitive market scenario.

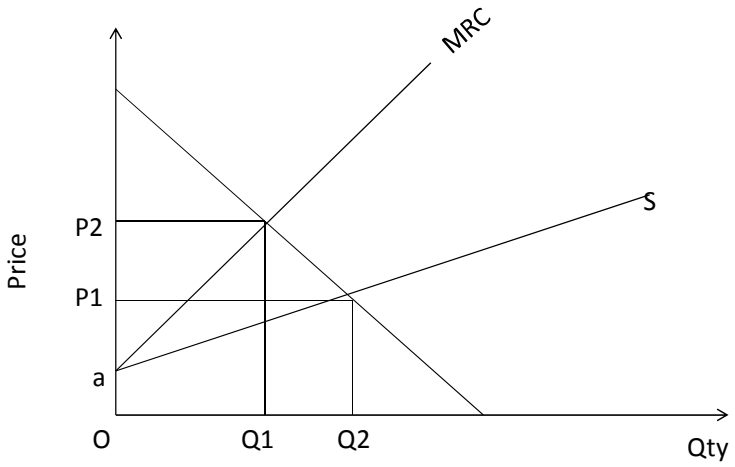
Market imperfection can be defined as anything that interferes with trade. This includes two dimensions of imperfections. First, imperfections cause a rational market participant to deviate from holding the market portfolio. Second, imperfections cause a rational market participant to deviate from his preferred risk level. Market imperfections generate costs which interfere with trades that rational individuals make or would make in the absence of the imperfection. According to Hymer, market imperfections are structural, arising from structural deviations from perfect competition in the final product market due to exclusive and permanent control of proprietary technology, privileged access to inputs, scale economies, control of distribution systems, and product differentiation, but in their absence markets are perfectly efficient.

The persistence of imperfect information across markets has contributed significantly to unsustainable production and consumption patterns. On the other hand, our examples illustrate how innovative entrepreneurs can develop solutions that help lead markets towards sustainability. As the collective knowledge of environmental degradation caused by unsustainable practices continues to grow, we are likely to see increasing pressure from policy makers, consumer groups, environmental activists, employees and others for firms to introduce innovative solutions to these problems in the hopes of stopping or even reversing environmental degradation patterns.

In imperfect competition buyer has to pay higher prices for resources to acquire additional resource (say land). In this case marginal resource cost (MRC) of resource is equal to price and not to the additional cost.MRC is the increase in the total cost of land from buying an additional unit of resource (say land).

Equilibrium price in these case $p_2 > p_1$ and equilibrium quantity is $Q_1 < Q_2$

In imperfect market the resource owner charge higher proices and supplied less quantity than in perfect market where price = quantity



Equilibrium in imperfect market for resource (say land).

Market and non market valuation of natural resources.

The economic value of natural resources can be estimated by the price individuals will pay in order to obtain the benefits of the resources. The non-market values of that communities attach to natural resources, such as recreational, existence and protection values. To support efficient decision making, environmental valuation techniques are needed to quantify the value impacts resulting from changed catchment management. Several approaches to environmental valuation are there i.e. revealed preference techniques include travel cost and hedonic pricing methods, stated preference techniques include contingent valuation and choice experiments. Stated preference techniques are increasingly being used to estimate non-market values. Nonmarket valuation is a method to estimate the value of goods and services that are not commonly bought and sold in markets.

Non-market valuation is a sub-field within environmental economics that deals with theoretical and practical aspects of estimating monetary values on non-marketed environmental goods and services. Specifically, techniques include the travel cost method of recreational demand, the hedonic property pricing model, averting behavior analysis, contingent valuation, contingent rating/ranking, and stated choice experiments.

Benefit-cost analysis

Benefit-cost analysis is a systematic method that compares the accumulative social benefits with the opportunity costs. Benefit-cost analysis can be more difficult to apply when the benefits or cost do not have a market value.

Travel Cost Model

The travel cost model estimates the implicit price of natural resources based on outlays of time and travel expenses. An evaluation of these costs incurred in using a natural resource (e.g. a state park) can be used to estimate the regional demand for the resource. The aggregate value of the resource can then be inferred from a combination of this demand and the number of visits to the site over time. This model can be applied to many recreational activities that utilize the more intangible natural resources such as bird watching.

Random Utility Models

The random utility model is similar to the travel cost model except that rather than focusing on the number and overall costs of trips to different sites, it estimates the value individuals place on particular sites based on the attributes of the site.

Hedonic Pricing Methods

Hedonic pricing methods involve a comparison of specific sites that differ only by some environmental attribute such as proximity to a forested area or availability of a view. Comparison of the property value between two house sites provides an indication of the value to the individual paying a higher price for the site with the preferred attribute.

Contingent Valuation Method

The contingent valuation method is a survey- or questionnaire-based approach to estimating the value of non-market goods. This is the primary method used for placing value on resources that cannot be valued by the indirect methods. This is the only method that can be used to estimate "existence values".

Existence value:

This is the value that individuals place on natural resources that they want to remain unaltered, even though they may not use or visit the area.

Economic value:

It is one ways to measure the value of a resource. Economic values are useful to consider when making economic choices – tradeoffs in allocating resources. Measures of economic value are based on individual preferences

Valuation:

Ecological and Environmental Economics

Habitat : Opportunity cost approach, Replacement cost approach, Land Value approach &
Contingent Valuation Approach

Air and water quality: Cost effectiveness of prevention, Preventive expenditure, Replacement - reallocation costs, etc

Recreational: Travel Cost Approach and Contingent Valuation Approach.

Aesthetics, biodiversity, cultural, historical assets: Contingent Valuation Approach

Use Values (i.e., personal use):

Use Values are divided into market and non-market commodities:

a. Market commodities are those which are traded in competitive cash markets. Private timber is a good natural resource example of a market commodity.

b. Non market commodities involve public goods, open access or unique resources potentially constituting natural monopoly situations.

ii) option value: willingness to pay by a person to guarantee that a resource would be available should he/she choose to use it in the future.

2. Non Use Values:

i) Bequest value: WTP by a person so that a resource might be passed on to future generations.

ii) Existence value: WTP by a person so that a resource will continue to exist today even if he/she never uses the resource. There is no personal use.

Common methods for estimating prices for publicly provided natural resources:

A. Market or Quasi-Market Methods of Price Estimation:

1. **Competitive market transaction data** - Competitive price information from actual private market transactions as a basis for valuation. i.e. Private market annual timber sales data is good example of market transaction data.

2**. Residual valuation** - used in situations where private markets for natural resources may not be active.

3. **Change in net income** - The general idea behind this pricing method is to estimate what the natural resource contributes to producer's profits (net income),

B. Non-Market and Non-use Methods:

1. **Travel cost method (TCM**):

It is most widely-used method for determining the demand WTP for outdoor recreation sites. It is a revealed preference method. TCM was first suggested by Hotelling and later Clawson, and has since been used extensively to estimate demand for recreation sites.

1) **Hedonic TCM**

Define Hedonic method - the Hedonic price method is used to estimate the value of an attribute (e.g., site quality) of a good (e.g., recreation site). In other words, the hedonic model, the multiple regressions, decomposes the total value of the good into the value of its several attributes.

2**) Random Utility Models**

RUMs are used to measure the economic impacts of changes in recreation site quality. It is a type of TCM. RUMs use the form of a multinomial logistical

regression model (i.e., logit model) where the predicted dependent variable (i.e., probability of visit given values of independent variables) is restricted to lie between the unit interval, 0 to 1.

3. Contingent valuation method

Many important valuation problems are non-observable; i.e., no value measures can be derived from observing individual choices in a market. Some of these situations involve potential rather than actual policy changes. Such cases call for value measurement methods which use hypothetical, constructed markets.