UNIT: 1 INTRODUCTION:

1.1 Concept and scope of forest Resource economics:

Concept:
Definitions

Forest Economics is a discipline that studies the production, distribution, and consumption of forest products and services. It characterizes the mental calculus of a decision maker, whether a private landowner or a policy maker, by focusing on the relationship between ends and scarce means (resources) that have alternative uses (Robbins 1932). In other words, forest economics is the study of choices relating to forest conservation and management.

Technical Information

While some features such as long time frames in production, production of multiple products (timber and non-timber products), and multiple stakeholders make forest economics somewhat unique and challenging, it draws heavily from the main field economics and thus can be considered as an off-shoot of conventional economics. For example, theory of supply and demand, which attempts to describe, explain, and predict the price and quantity of goods and services produced and consumed in competitive markets, is the basis for a wide range of forest economic analysis. The marginal approach, wherein the price level is determined by the marginal cost and marginal utility, which became increasingly important in economic theory in the late 19th century is central to forest economics. Furthermore, forest economics also adopts both positive and normative approaches, respectively, to explain economic phenomena or behaviour (timber supply or timber consumption for example) and to set rules, prioritize choices/actions by a set of criteria. Institutional economics, which focuses on understanding the role of human-made institutions in shaping economic behaviour; Pareto improvement, a fundamental principle of welfare economics which states that a movement from one allocation to another that can make at least one individual better off without making any other individual worse off; and neo-Pareto improvement--if potential gains of movement from one allocation to another outweigh potential losses—are extensively used in forest economics.

Forest Economic Methodologies

Forest economic models can be viewed as abstract representations of the real world useful for hypothesis generation, forecasting, policy analysis and decision-making (Buongiorno and Gilles 2003). Some are designed to assess simple cost and benefits of outputs and inputs for which markets are fairly established while others are amenable to assess a variety of environmental services and damages for which there are no established markets (Alavalapati and Mercer 2004). Furthermore, some methodologies are more appropriate for assessing issues at a forest stand or household level while others are more applicable at landscape or regional and national scales. Following are some of the commonly used models in forest economics:
Partial budget models to estimate profitability of a forestry enterprise.
- Optimization models to estimate land expectation values assuming that the land will be used for forestry (the best possible productive use) in perpetuity.
- Linear and non-linear programming models to estimate optimum resource allocation subject to various constraints faced by the decision-maker.
- Econometric models to estimate the relationships among variables under investigation for forecasting, policy analysis, and decision-making.
- Stated and revealed preference based contingent valuation models to estimate values for environmental goods and services such as recreation, soil conservation, and water quality.
- Economy-wide models such as input-output, social accounting matrix, and computable general equilibrium models to estimate income, employment, and price levels at regional or national level, in response to a policy or program.

**Traditional economics versus forest economics:**

<table>
<thead>
<tr>
<th>Traditional economics</th>
<th>Forest economics</th>
</tr>
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<tbody>
<tr>
<td>1. It deals with the interrelationship and interactions between the forest and economic activities in very low extent.</td>
<td>1. A nascent sub-discipline of economics that deals with the interrelationship and interactions between the forest and economic activities.</td>
</tr>
<tr>
<td>2. Deals with private goods that are bought and sold in markets.</td>
<td>2. Deals with private goods that are bought and sold in private market as well as deals with public or collective goods for which either no market exists or the market are imperfect.</td>
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<tr>
<td>3. Does not take into account externalities associated with the actions of individual, groups of individuals and organization.</td>
<td>3. Takes into account the externalities associated with the activities of individuals and groups of individuals and organizations.</td>
</tr>
<tr>
<td>4. Time related decisions such as allocation of resources over time and inter-generational equity do not receive much attention.</td>
<td>4. Time related decisions and inter-generational equity receive high attention.</td>
</tr>
<tr>
<td>5. Often does not consider the limited capacity of forest to provide inputs for production and absorb wastes produced in the process of production.</td>
<td>5. Limited capacity of the forest is explicitly considered.</td>
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</table>

**Scope and importance:**

Forest economics is the application of micro-economic principles to forestry's managerial and decision making problem.
Knowledge of forest economics enables professional foresters to appraise and analyse the problems of demand and supply of natural resources and to devise ways and means of rendering them compatible with available resources and constraints. Forest economics helps a forester to lay more emphasis on planning and development, to critically analyses impact of the dictates of the silvics and silviculture, ecology, environmental conservation, geology, rock, wildlife and to influence the management practice in overall human interest. Economics of forestry helps a forester to make better recommendations and judgment and to be an intelligent, active and constrictive participant in forestry event so that forestry sector contributes its best to the economic well being of society. Hence, following are the scope and importance of forest resource economics.

- Allotment of forest land to protection forest, productive or commercial forest, social forest etc. for the protection of environment.
- Selection of tree crops suitable for protection of land from soil erosion, determination of land use patterns involving a combination of engineering, horticulture and animal husbandry, and forestry project of flood control.
- Assessment of the extent of employment potential of forestry.
- Intensive utilization of major and minor products sustainably.
- Giving more stress on plantation activity which is highly labour intensive, results the more employment opportunity.
- Value addition to the forest products.
- Economic use of forestry products.
- Determination of rotation, implication or restore to artificial regeneration, natural regeneration.
- Determining the pricing policy for supply of raw materials to forest based industries.
- Formation of policy for the export of forestry products.
- Formation of policy regarding to the basis of distribution of forest product to individual and to fix their quantity also.
- To analyse people's involvement and participation in forest as well as wildlife management.
- Protection of endangered species.
- Forecasting the future requirement of forest product.

Role in forest resource management:

- Problems of forestry can be adequately appreciated and addressed only by study of forest economics, and financial aspects of any forestry operation alone cannot lead to wise decisions regarding forest management.
- A mere study of business issues of forest industries cannot give the overall and well-balanced approach to forest management that is required for the welfare of society as whole, but forest economics fulfill the gap.
- Forest economics deals with economic problems involved in buying, owning, selling, taxing and managing forest land, whether used for production of water, wildlife, wood or any other product. Managing forest land, of course, can mean growing, protecting,
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harvesting and marketing the product of that land. Hence role of forest economics in forest management is crucial.

- The problems involved in management of a forest consisting of a mixture of stands of several ages and species, determination of the best way of scheduling their cuts and ordering optimal cultural operations are the field of forest management as well as forest economics.
- Due to the crucial role of forest economics in forest resource management, it will be relevant to give the name of forest economics as forest management economics, which deals with all economic problems concerning the growing of forest and producing all products like timber, wildlife, water, outdoor recreation and forage from forest land.

In a nut-shell forest economics gives the each and every answer of forest management objectives and problems facing the forest management. Hence forest economics relates to economic theory necessary to forest management and forest management is the practice or use of such theory originated form forest economics. Forest economics is the applied theory of economics in the field of forestry and forest management is its application.

Relevance of economic theory in forest resource management:

By rigour study of economic theory one can set the management objectives of a particular forest as well as forest management alternatives. In the broadest sense forest management is integrates all of the biological, social, economic and other factors that affect management decisions about forest. Hence economic theories are related directly with forest management. Following points which are the area of economic theory must be adopted while managing the forest.

- Choice between alternative course of action; eg choice the location of a new mill may not only affects the firm's profitability but also local employment.
- Choice among the alternatives that is most useful or least costly.
- If production is widely defined valuing the resource consumed in that production activity.
- Maximization of production value.
- Use of scarce resources while managing a forest.
- For the same expenditure in forest management 5000 cft timber is preferred to 2000 cft timber or Rs 1000 worth of forest product is preferred to Rs 500 worth.
- Valuation methods of forest products, eg wood, water, range, wildlife and recreation.
- Non-market valuation of forest product.
- Units of measurement while valuing the forest product.
- The demand value of a particular forest product and services.
- The supply value of a particular forest product or services.
- Fixing the price of a particular forest product or services.
- Theory of capital budgeting, investment and interest.
- Risk and uncertainty of forest management.
- The economic base and importance of forest and forest based industries.
- Forest land base that is supporting the forest product industry, particularly the ownership pattern.
• Demand side of the market for forest products and their elasticity.
• Supply side information including stumpage price and its short-run and long-run supply response.
• Demand for outdoor recreation and other environmental services.
• Paying environmental services (PES)

1.2 Economic history of forest management and conservation:

**Historical Issues**

One of the economic issues relating to forest management that can be traced back to the beginning of nineteenth century is forest land valuation and optimal timber harvesting age. Faustmann (1849) proposed an approach to assess the value of land under forestry in perpetuity by solving for optimal timber harvest age. In the last three decades several successful attempts were made to extend the Faustmann approach to incorporate complex issues such as stochastic nature of prices and costs, interest rates, timber yields; imperfect market conditions; and non-timber products and services (Hartman 1976; Fina et al. 2001; Stainback and Alavalapati 2004).

Estimation of timber supply and demand, identifying the gap between the supply and demand; and domestic and international trade in forest products at regional, national, and international level have been the key issues in forest economics. Sedjo and Lyon (1990) provided a global perspective on long-term adequacy of timber supply based on economic theory of long-run adjustments in timber harvests and global timber production and trade. Sills and Abt (2003) recently edited valuable research reviews on economics of timber and nonmarket supply, demand, and international trade analyses of forest resources.

The objective of managing forests for both timber and non-timber products (biodiversity and recreation for example) have prompted forest economists to pay increasing attention to optimizing multiple objectives. Economics of multiple-use forestry explored by Bowes and Krutilla (1989) laid foundations for valuing non-market services of forests and incorporating them into forest planning.

Several forestry issues that are on the horizon warrant rigorous economic analysis. For example, economic and distributional impacts of carbon markets and forest carbon sequestration, forest certification, and use of forest biomass for energy production are not well understood and forest economics is expected to play key role in addressing these issues. In addition, Kant (2003) noted that existing forest economic models are limited in that they do not address the issue of multiple equilibriums and consumer choices that incorporate context specific and dynamic preferences and called for extending the boundaries of forest economics.
<table>
<thead>
<tr>
<th>Yr(A.D.)</th>
<th>Chronological event</th>
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<tr>
<td>1847</td>
<td>Nepal collected about NRs 56,000 from timber export to India</td>
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<tr>
<td>1862</td>
<td>Promulgation of Mulki Ain with provision of tree cutting with restrictions on cutting trees in public lands: prohibited in protected areas, road sides, water sources while landlords allowed to cut trees on their land and farmers to kill wild animals for depredation of crops.</td>
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<tr>
<td>1887</td>
<td>Substantial revenue from timber (NRs 2.35 million?)</td>
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<tr>
<td>1901</td>
<td>First sawmill established</td>
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<tr>
<td>1903</td>
<td>Sal logs exported to India for railway slippers</td>
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<tr>
<td>After 1913</td>
<td>Working plan office established with British forest officers</td>
</tr>
<tr>
<td>1922</td>
<td>Forest clearance at massive scale in Chitwan and Makwanpur</td>
</tr>
<tr>
<td>1927</td>
<td>Before 1927 no administrative offices, Distribution of lands for farming</td>
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<tr>
<td>1939</td>
<td>Establishment of “Eastern Wing and Western Wing” To manage the supply of sleepers to India and collection of Revenue.</td>
</tr>
<tr>
<td>1942</td>
<td>Kath Mahal Adda established – 3 circle and 12 forest check post</td>
</tr>
<tr>
<td>1950</td>
<td>2 circle, 11 Division and 44 range-posts and in 1951 Forest Department established, at the advice of Padma Dutta Rataudi</td>
</tr>
<tr>
<td>1957</td>
<td>Nationalisation of private forests</td>
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<tr>
<td>1959</td>
<td>Nepal Forest Service started, Establishment of Ministry of Forest (MOF) To cover forest activities nationwide.</td>
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<tr>
<td>1960</td>
<td>Forest Institute established, MOF abandoned due to lack of staff</td>
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<tr>
<td>1961</td>
<td>Establishment of TCN To utilize timber from resettlement areas. Protection oriented laws were enabled (1961,1967,1970),</td>
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<tr>
<td>1966</td>
<td>Establishment of Fuelwood corporation</td>
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<tr>
<td>1967</td>
<td>Formulation of especial Forest protection act To enable the forest conservation &amp; protection activities. DFO became policing and Lawyer.</td>
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<tr>
<td>1968</td>
<td>Establishment of 14 circles, Pradhan Ban Karyalaya</td>
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<tr>
<td>1970</td>
<td>Formulation of Forest production rules. To restrict, control and collect the revenue</td>
</tr>
<tr>
<td>1974</td>
<td>Department of Soil Conservation established</td>
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<tr>
<td>1976</td>
<td>National Forestry Plan (9 circles and 40 Divisions covering 75 districts).</td>
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<tr>
<td>1978</td>
<td>Forest Act 1961 was amended to incorporate the provisions of Panchayat and Panchayat Protected Forests.</td>
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<tr>
<td>1980</td>
<td>Department of National Parks and Wildlife Conservation established</td>
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<tr>
<td>1988</td>
<td>Implementation of Forest Sector Master Plan</td>
</tr>
<tr>
<td>1990</td>
<td>Re-organisation of DoF with 74 DFO, 92 Ilaka, 698 Rangepost</td>
</tr>
<tr>
<td>1993</td>
<td>New Forest Act. National forest is handover to the adjoining forest users for accountable management.</td>
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<tr>
<td>1995</td>
<td>Forest regulations. To launch the forest management programs according to the Forest act 1993.</td>
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</table>
Forest policies in Nepal

Past policies (till 1960)
Export of timber (India oriented, revenue focused)
Forest Organisation
Lack of professional commitment & ownership
Lack of government’s priority

Middle period (1961 – 1990)
Legislative framework
National forest plan and MPFS
Participatory forest management
Massive plantations
Forest resources information

Recent policies (1991 – present)
Donor driven programme
Community forestry, participatory conservation and recently collaborative
Training and institutional strengthening
New forest act and participatory legislation

Policy failure and The World Bank’s Pedantic Forecast:
Forest Nationalisation Act 1957 promulgated to protect and manage the forests as national property, accelerated deforestation and resource degradation. Government implemented the Forest Act (1961) and Forest Protection Special Act (1967) for strict protection however, the destruction of forest resources continued.

In late '70s, The World Bank made prediction regarding forest situation of Nepal. On the basis of estimated deforestation trends, the Bank predicted that there would be no trees left in the Hills of Nepal by 1993 (Bartlett and Malla, 1992: The World Bank, 1978 as cited by Griffin, 1988). It was a classical Malthusian forecast of a country where the forests are still under indigenous management and are not subjected to the 'Tragedy of Commons' (Gilmour, 1990). Nevertheless, The Bank's report created a wide interest, among the donors and multilateral agencies, to assist in Forestry Programs in Nepal.

National Forest Plan:
National Forest Plan, 1976 paved the way for the emergence of Community Forestry in the country. The initial efforts in Community Forestry, while overly emphasising protection of forest resources, concentrated mainly on establishing nurseries and plantations. The main Policy of the Government then was to restore the degraded forest areas in the Hills.
**Master Plan for the Forestry Sector Nepal 1988 (MPFS, 1988):**

Objectives:
- restoration of nature-balance,
- economic mobilisation,
- scientific management, and
- Promotion of public co-operation.

Community and Private Forestry Programme as the priority program: ‘people centred forestry’

The Plan was geared to
- rural institutional building,
- greater self-reliance,
- management flexibility and
- empowerment of deprived and poor section

The Plan provided a 25-year policy and planning framework for the forestry sector of Nepal. The Plan envisaged handing over of forests to the traditional users for fulfilling forest related basic needs in the hilly areas of Nepal.

**Forest Management Paradigm:**

Last six decades witnessed a shift in paradigm of forest management in Nepal. In early days, the local people employed watchers to protect nearby forests for satisfying the domestic needs (Fisher, 1989)

Nationalisation and subsequent failure of management efforts turned forests into open access resource with a free-ride tendency among the villagers.

**National Forestry Plan 1976 with the objectives:**

Restoration of nature-balance, economic mobilisation, scientific management, and promotion of public co-operation, paved way for participatory management practices in Nepal.

**Custodial Element in Forestry:**

Panchayat forest and Panchayat protected forest rules, failed in participatory management - managerial responsibility rested on local political entity. Moreover, handover of the forest was based on political boundary without proper identification of traditional use rights. These changes neither created environment for villager's participation nor entrusted them with an authority to protect, manage, and utilise the forests. Hence, the status of “custodial element” remained unabated (Anonymous, 1991).

: End of this unit:
UNIT: 2
THEORY OF OPTIMIZATION

Optimization:
Optimization is the choice from all possible use of resources of that which gives the best result. This is often represented by maximizing an objective function. Critics of optimization argue that there are unlimited numbers of different ways of using given resources. People actually choose between a very limited number of the possibilities, using often crude 'rules of thumb' both to select the possibilities considered and to choose between them.

2.1 Treatment of time on production:
There are two types of economic decisions regarding production and consumption.
1. Choice between one commodity and other, at the same point in time, spatial decisions.
2. Choice between same commodity or activity but at different points in time, temporal decisions.

If a firm decides to produce building materials (like doors, windows) rather than furniture from its supply of logs it makes a spatial decision. But when one decides whether to buy a car now or save the money in a bank so as to be able to pay his debts next year he is making temporal decisions. These two types of decisions are not mutually exclusive. Often an economic agent makes decisions that have both spatial and temporal aspects. Basic ideas and techniques that are required in making temporal decisions and in understanding economic behaviour regarding inter-temporal issues are the subject matter of treatment of time on production.

2.1.1 Time value of money:
The time value of money is a notion concerned with the impact of time on investment decisions and holds overall pervading on capital investment and its progressive proliferation. (M.M Pant)

Interest rate:
Interest is the cost of capital or cost of credit or opportunity cost of capital. Any borrower normally has to pay the lender more than the principal originally received: the excess is interest. The rate of interest is the interest which has to be paid for a 1-period loan as a percentage of the principal. This is normally expressed as a rate per annum.

Real interest rate:
It is the real return on loans. This is the money return, adjusted for inflation. If the nominal interest is 100i percent and the rate of inflation is 100p percent, the real rate of interest of 100r percent is given by-

\[(1 + r) = \frac{(1 + i)}{(1 + P)}\]

Or, \[r = \frac{(1+i)}{(1+p)} - 1\]
**Market interest rate:**
The market rate of interest is the rate at which an investor actually pays to the lender for the use of money so borrowed or the lender actually receives from the borrower for making the sum available to him for a specific period of time. The market rate of interest reflects the opportunity cost of capital. Generally there are at least two interest rates in a market, one is lending and the other is borrowing rate. The borrowing rate is generally higher than the lending rate. The main reason for this difference is the administrative expenses of the organizations involved in this business. Sometimes there are various lending and borrowing rates in a market. This is mainly because of the market imperfection and risk factors involved when money is lent. If the risk factors are excluded from the market rate of interest it is often called pure or economic rate of interest.

**Discount rate:**
The interest rate at which future receipts or payments are discounted to find their present value is called discount rate.

**Principal amount:**
The amount of money originally invested is called the principal amount.

**Future value:**
The amount of money to which it will grow when the interest is added up is called future value.

**Present value:**
The value today of a future payment is called the present value.

**Compounding:**
Calculating the future value of a payment or series of payments is called compounding. The payments are compounded forward to some future year n. compounding formulas are used to calculate the future value. The result so obtained is said to the future value.

**Formula:**
\[ v_n = v_0 (1 + i)^n \]

Where,
\( v_n \) = the future value of a single payment in year n;
\( v_0 \) = the present value of single payment.
\( i \) = the interest rate.
\( n \) = the year in which payment occurs.

**Discounting:**
Calculating the present value of a future payment is called discounting. Payments are discounted to the present. Discounting formulas are used to calculate the present value.

**Formula:**
\[ v_0 = \frac{v_n}{(1 + i)^n} \]

Where all variables are as defined in the compounding formula;
To find the interest rate:

\[ i = \frac{n}{\sqrt[n]{v_n} - 1} \]

Where all variables are as defined in the compounding formula;

To find the number of years:

\[ n = \frac{\log \frac{v_n}{v_0}}{\log (1 + i)} \]

Where all variables are as defined in the compounding formula;

2.1.2 Social interest rate and its effect on production:

Social interest rates or social rate of discount (SDR) is the rate at which society discount future values as compared to the present values. Because of the limited span of human life as compared to an endless, continued but dynamic life of a society as a whole, the individual time preference is much higher than that of society. Society has a much longer life expectancy and it tends to take a long view of utilization of resources. Hence the social interest is risk free.

We know,

\[ E_i = \frac{p_i + R_i}{100 - R_i} \times 100 \]

Where,

- \( E_i \) = Effective rate consisting of pure rate plus risk rate.
- \( p_i \) = Pure rate in percent.
- \( R_i \) = Risk rate expressed as a percent of expected annual loss of capital invested.

For public project investments the risk is zero, i.e. \( R_i = 0 \)

Therefore, \( E_i = p_i \)

Hence, rate of discount or interest = Social interest rate or SDR for public project.

Therefore, private / individual time preference is higher than social time preference.

Effect on production:

- If two low social interest rate is used – investment activities increases and through which production increases, too much production may be bad for society.
- Using too high social interest rate could lead to leaving savings unutilized and cause excessive unemployment- again may be bad for society.
- The probability of a species becoming extinct can be high when high interest rates, in conjunction with low growth rate. Low costs of harvesting and high value of the harvested resource, lead to a low stock size. In some case, economically efficient stock sizes can be zero.
In spite of these facts regarding to the forest resource management we must use lower SDR or social interest rate due to,

- In public forestry, the benefits and profits go back to the people and are thus ploughed back.
- In fact the social value of some forests, particularly those in the hills and riverian site, are far greater than their value in terms of marketable output.

2.2 Production of renewable natural resources:

A resource should satisfy any of the two basic preconditions. A physical substance is not a resource unless any one or both of the following criteria are satisfied.

- There must exist a demand for the physical substance directly or indirectly either in human society or in any part of biological kingdom.
- The knowledge and technical abilities should exist for extraction and utilization of the physical substance.

Resource classification:

Rees (1990) classifies natural resources into two types;

1. Stock resources:
   - Fossil fuels like oil, coal, gas etc.
   - Non metallic elemental minerals like carbon.
   - Recyclable resources such as metallic minerals.

2. Flow resources:
   Flow resources or moving or growing resources comprising of critical zone resources that can be exploited to exhaustion such as fish, forests, animal, soil, water in aquifers etc. and non critical zone resources that cannot be exhausted by human use but can be modified, such as solar energy, tides, waves, water, air etc.

Owen (1971) has classified resources into two types:

1. Inexhaustible resources- that are never finished. Further divided;
   a. Immutable resources: they are rarely or never changed by anthropogenic interference, such as wind power, solar energy, nuclear energy, tidal power etc.
   b. Misuse able resources: that can be degraded in quality because of misuse, although these are never exhausted these resources include water in ocean, air in atmosphere etc.

2. Exhaustible resources: that is exhausted if used improperly. These resources are categorized into
   a. Nonrenewable resources: include mineral ores, fossil fuels that once used cannot be renewed.
   b. Renewable resources: such as forests that can be rationally used and sustainably developed, although different endangered species need continuous protection for renewing their population and thus do not permit rational use.
Product taxonomy of renewable natural resources:

1. **Forest**: Eg timber, wildlife habitat, aesthetic value, recreational services, carbon sink, scientific purpose. (multiple product and multiple services)
2. **Fisheries**: Fresh water fish, salt water fish.
3. **Soil**: soil fertility.
4. **Wetland**: Multiple product and multiple services.
5. **Animal population**: Multiple product and multiple services.

What really production of renewable natural resources mean?

- Economics of renewable natural resources use.
- Management of RNR.
- How society should exploit a RNR efficiently.
- The rate at which a rational firm or government as a whole should exploit such resources.
- How to maintain the flow of RNR over time.
- Harvesting rate and natural rate of regeneration.

Central idea of RNR Production:
Because of the fact that renewable natural resources are naturally regenerated on a time frame that is relevant to human exploitation. Catching a fish or cutting a tree does reduce the population of fish or tree in any period. But unless the population has already been reduced to the point of critical threshold, natural growth will replenish that loss of biomass due to the harvest within the relatively short period. So, although it is true that a renewable resource can be exhausted, it need not be.

Stock and flow:
Differentiate:
- i. Fish, animals, birds and forest:
- ii. Coal, natural gas, petroleum and minerals:
Fish, animals, birds and forest consists of populations of individual organization that reproduce, grow and die.

Similarity:
One similarity between renewable and nonrenewable resource is that both are capable of being fully exhausted (that is, the stock is driven to zero) if too much harvesting and extraction activities are carried out over some time period.

Stock:
The stock or population, is a measure of the quantity of the resource existing at a point in time, measured either as the aggregate mass of the biological material (the biomass) in question (such as the total weight of fish of a particular age class or the cubic meters of standing timber) or in terms of population number.
Flow:
The flow is the change in the stock over an interval of time, where the change results either from biological factors, such as the entry of new fish into the population through birth (called recruitment) or the exit from the population due to natural death or from economic factors such as harvesting of the species in questions.

Biological dimension- growth curve:
The size of stock, as a function of time:
Let $S_t$ denote the mass of the resource stock at time $t$. The amount of growth of resource stock, $G$, is a function of the size of the resource stock itself. This is known as density dependent growth. Hence biological growth function can be written as;

$$G_t = G(S_t)$$

Or the absence of human predation the following identity relates stock and flow of the renewable resources.

$$\frac{dS_t}{dt} = G(S_t)$$

- Figure show the population dynamics of a hypothetical renewable resource, which we assume to be a single fish species. This shows cumulative growth.
• The curve as we have drawn begins at $X_{\text{min}}$ the critical minimum level of population. If the size goes below this level the species is driven to extinction. ($X_0$)
• At low levels of stock the fish multiply, but as they begin to compete for food their rate of growth slows down and eventually the stock converges on some maximum level $X_c$, the ecosystem carrying capacity for that species (in the absence of human intervention).

**Relationship between resource stock and growth:**

![Diagram of growth and resource stock relationship]

- In the figure the growth on the resource stock is shown in the vertical axis and the level of stock ($X$) on the horizontal axis.
- $X_{\text{min}}$ in the diagram is known as the minimum viable population and that represents the level of population below which growth in population is negative.
- With human intervention when harvest (yield) level equals the growth of stock it is known as sustainable yield. Thus in terms of figure $G(X_1)$ is the sustainable yield for resource stock $X_1$.
- The maximum sustainable yield (MSY) takes place, when the growth of the resource is at a maximum. It is a $G(X_m)$ corresponding the MSY stock $X_m$.
- The apparent attraction of MSY should be obvious; if we harvest the renewable resource in such a way that we take MSY from the stock, it will regenerate itself and we can get MSY again. If takes ten years, we must harvest MSY every ten year only.

2.3 Economic Method of multiple productions:
**Silent features of multiple productions:**

**A Joint production:**
In the real world, the firms are generally multi-products firm that is they produce more than two products. This type of case is joint production. Sheep raising is the most familiar example of a single production process yielding joint products. Two products wool and mutton can be jointly produced in varying proportions by a single production process. Two types of joint production may be distinguished.

**Technically fixed proportions**—Wheat and straw, beef and hides, mutton and wools etc; joint production with technically fixed proportion can always be reduced to the single product case. If for example, in studying a particular sawmill one should find that 500 kg of saw dust can be
produces with every 2000 cft of sawn wood, the problem of joint production can be solved by
treating this as a "combination" product.

**Technically variable proportions**- In this type, products have the particular characteristics that,
although joint use of some productive factor of service is involved, the production in which the
products can be produced may be varied. A given hectare of forest can be made to yield saw
timber and pulp wood in varying proportions. The same holds true for a particular tree, while
nearly every log can be cut to yield varying proportions of high and low grade timber.

**B. Rival production:**

**The production possibility frontier:**

From the given resources it is possible to produce nothing, by leaving it unused, or produce
different combinations some of which may be better than others. The combination represented by
M, for example, is definitely better than that represented by N because it has more of X as well
as more of Y than in the combination represented by N. It is not possible, however, to say
whether T is better than N because both X and Y are not more than those at N here. T has more
of Y but less than N and we have no way of deciding how to compare the relative value of X and
Y. This type of situation is rival production of output X and Y as given by the boundary of same
production possibility frontier.

Rival product may be timber and forage, timber and fuelwood etc.

**Firm's integration:**

When a firm produces more than one output the parts of the firm's business concerned with a
particular product or a group of similar products is called an enterprises. A single forestry firm
may, therefore, have a timber growing enterprise, a wildlife enterprise, a sawmill enterprise and
other enterprise. A combination of more than one enterprise in a firm is called integration. There
can be two main type of integration.

- **a. Vertical integration:**

  When enterprises representing successive links in the economic chain of production in a
  firm are combined it is said that the firm is vertically integrated. A firm engaged in
growing tree and also in logging them is vertically integrated.

- **b. Horizontal integration:**

  When enterprises that use some of the same products
  are combined within a firm, the firm said to be
  horizontally integrated. A company that has both a
  lumber and pulp mill is an example of such a firm.
  The common input, log, is used for both the
  enterprises.

A single firm can be both vertically and horizontally
integrated. In facts large forestry firm are often integrated
both ways. They may have a woodlands section which
produces raw material for its lumber and pulp mill and also a
logging section that serves both the mills.

Multiple products of a firm can be usefully put in one of the
two groups: (1) vertically related products and (2)
horizontally related products.

**Economic Method:**

**Firm’s equilibrium:**

Two conditions must be satisfied;

- MC = MR
- MC must cut MR from below.

1. In case of single product production firm there is only one cost curve and revenue curve.
2. But, in case of multiple product production firm, there is only one cost curve, as many revenue curves as many products.

**Optimization:**

a. Minimization of cost, for given level of output, given level output should be maximum profit level.
b. Or, maximization of revenue, from least cost combination.

- In the single product case marginal analysis approach is sufficient for describing the economic method of production. The analysis can be made by the usual technique - analysis of separate production and cost function independently. The interesting case arise when the same production facility - the same factory - is used to or more products. This is the case of joint production, so called because at least one of the factors, often the entire groups of fixed factors, is jointly used.

- Joint production with technically fixed proportion can always be reduced to the single product case, in this case we can use marginal analysis easily; means marginal cost can be derived but average cost cannot be derived.

- The usual practice in forestry firm, which produce vertically related products is that the output of the first product in the production chain, that thought to maximize profit, is planned to be produced. But in case of imperfectly developed markets and government regulations, case may be of each enterprise to maximise its profit by producing at the point where its marginal revenue equals its marginal cost.

- In case of horizontally related products, the optimal level of production of associate products can be obtained by treating the multiple products as a bundle and calculating the price of bundle from the price of the individual products. The optimal output can then be determined at the point at which marginal revenue from producing this bundle is equal to the marginal joint cost of producing it.

- Though the joint production level can be determined, the joint cost of production cannot be determined to each of the products by any kind of economic analysis.

**Economic method- for rival products:**
The Iso-revenue line should be tangent to the production possibility frontier (production possibility curve). The Production possibility frontier should be concave to the origin at the point of tangency. After fulfilling these two conditions, the rival multiple products of a firm will be economic.

2.4 Linear Programming:

Linear programming is a mathematical technique for determining the optimal allocation of resources and achieving the specified objective when there are alternative uses of the resources like money, manpower, materials and other facilities. The objective in resource allocation may be either cost minimization or profit maximization. The technique of linear programming is applicable to all problems in which the total effectiveness about the use of resources can be expressed as a linear function of individual allocations.

Basic assumptions:

1. There should be an objective which should be clearly identifiable and measureable in quantitative terms. It could be, for example, maximization of sales, of profits, minimization of cost, and so on.
2. The activities to be included should be distinctly identifiable and measureable in quantitative terms, for instance, the products included in a production planning problem.
3. The resources of the system which are to be allocated for the attainment of the goal should also be identifiable and measureable quantitatively. They must be in limited supply. The technique would involve allocation of these resources in a manner that would trade off the returns on the investment of the resources for the attainment of the objective.
4. The relationships representing the objective as also the resource limitation considerations, represented by the objective function and the constraint equation or inequalities, respectively, must be linear in nature.
5. There should be a series of feasible alternative course of action available to the decision maker that is determined by the resource constraint.

When these stated conditions are satisfied in a given situation, the problem can be expressed in algebraic form, called linear programming problem (LPP), and solved for optimal decision.
GENERAL STATEMENT OF LINEAR PROGRAMMING PROBLEM:

In general term, a linear programming problem can be written as,

Maximise \[ z = c_1x_1 + c_2x_2 + \ldots + c_nx_n \]  
Objective function.

Subject to
\[
\begin{align*}
    a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n & \leq b_1 \\
a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n & \leq b_2 \\
    \vdots & \quad \vdots \\
    a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n & \leq b_m \\
\end{align*}
\]
Constraints

Where \( c_j, a_{ij}, b_i \) (\( i = 1, 2, \ldots, m; j = 1, 2, \ldots, n \)) are known as constraints \( x_j \)'s are decision variables. The \( c_j \)'s are termed as the profit coefficient, \( a_{ij} \)'s the technological coefficient and \( b_i \)'s are the resources values. In shorter form, the problem can be written as:

Maximise
\[ Z = \sum_{j=1}^{n} c_jx_j \]

Subject to
\[ \sum_{j=1}^{n} a_{ij}x_j \leq b_i \quad \text{For } i = 1, 2, \ldots, m \]
\[ x_j \geq 0 \quad \text{For } j = 1, 2, \ldots, n \]

When the problem is minimize a function

Minimise
\[ C = \sum_{j=1}^{n} c_jx_j \]

Subject to
\[ \sum_{j=1}^{n} a_{ij}x_j \geq b_i \quad \text{for } i = 1, 2, \ldots, m \]
\[ x_j \geq 0 \quad \text{for } j = 1, 2, \ldots, n \]

In matrix notation; an LPP can be expressed as follow:

<table>
<thead>
<tr>
<th>Maximisation problem</th>
<th>Minimisation problem</th>
</tr>
</thead>
</table>

BY NP Upadhyaya
Maximise \[ Z = cx \]
Subject to
\[ ax \leq b \]
\[ x \geq 0 \]

Minimise \[ C = cx \]
Subject to
\[ ax \geq b \]
\[ x \geq 0 \]

where,
c = row matrix containing the coefficient in the objective function.
x = column matrix containing decision variables.
a = matrix containing the coefficients in the constraints.
b = column matrix containing the RHS values of the constraints.

Notes:
1. Generally, the constraints are;
   \( \leq \), type in maximisation problem;
   \( \geq \), type in minimisation problem;
   But a given problem may contain mix constraints. \( \leq, =, \geq \) Type.
2. Usually, the decision variables are non-negative. However, they need not always be so.
To illustrate, an investment problem, if we let \( x \) represents the amount to be invested in the
shares of a particular company, then
\( x \geq 0 \) We may decide to invest.
\( x = 0 \), We may decide not to invest.
\( x \leq 0 \), Disinvestment in this share.

Real problem:

Maximisation type | Minimisation type
--- | ---
Maximise \[ Z = 3x + 6y \]
Subject to
\[ 3x + y \leq 48 \]
\[ x + 3y \leq 48 \]
where,\( x \geq 0, y \geq 0 \)
(1OF, 2064) | Minimise \[ C = 50x + 40y \]
Subject to
\[ 6x + 3y \geq 30 \]
\[ 3x + 3y \geq 18 \]
where,\( x \geq 0, y \geq 0 \)
(1OF, 2067)

Formulation of LPP:

(1) In Pokhara, a firm produces Swan Timber and Fuel-wood at given prices of Rs 12 and Rs 15
respectively for each unit. To produce Swan timber, the firm requires 12 units of species A, 6
units of species B and 14 units of species C. Fuel-wood requires 4 units of species A, 14 units of
species B and 12 units of species C. Total available inputs in each cases are 48 units of A, 72
units of B and 84 units of C. Using simplex Methods of Linear programming, find out the two
products combination to be produced by the firm to earn the Maximum revenue. Discuss the
assumption upon which the linear programming is based. (1OF, 2060)

Solution:
Now, we will discuss only the formulation part of this problem:
Let, $x = \text{Units of swan timber to be produced.}$  
$y = \text{Units of fuel woods to be produced.}$

Constraints:

<table>
<thead>
<tr>
<th>Species</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>prices(Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swan timber(x)</td>
<td>12</td>
<td>6</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Fuel woods (y)</td>
<td>4</td>
<td>14</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Availability</td>
<td>48</td>
<td>72</td>
<td>84</td>
<td></td>
</tr>
</tbody>
</table>

Now, we can write the problem as follow;

Maximise

\[
Z = 12x + 15y
\]

Subject to

\[
12x + 4y \leq 48
\]

\[
6x + 14y \leq 72
\]

\[
14x + 12y \leq 84
\]

\[
x \geq 0, y \geq 0
\]

(2) A horticulturist wishes to mix fertilizer that will provide a minimum of 15 units of potash, 20 units of nitrates and 20 units of phosphate. Brand I provides 3 units of potash, 1 unit of nitrates and 3 units of phosphate, it costs Rs 120. Brand II provides 1 unit of potash, 5 units of nitrates and 2 units of phosphate, it costs Rs 60. Find the quantities of two brands, which should be mixed such that cost is minimum. Find also the minimum cost graphically.

**Solution:**

Now, we will discuss only the formulation part of this problem:

Let, $x = \text{Number of bags of brand I.}$  
$y = \text{Number of bags of brand II}$

Constraints:

<table>
<thead>
<tr>
<th></th>
<th>Potash</th>
<th>Nitrates</th>
<th>Phosphate</th>
<th>Costs(Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brand I (x)</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>120</td>
</tr>
<tr>
<td>Brand II (y)</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>60</td>
</tr>
</tbody>
</table>

Now, we can write the problem as follow;
Minimise  
\[ C = 120x + 60y \]  
Objective function

Subject to

\[ 3x + y \geq 15 \]  
Potash constraints

\[ x + 5y \geq 20 \]  
Nitres constraints

\[ 3x + 2y \geq 24 \]  
Phosphate constraints

\[ x \geq 0, y \geq 0 \]  
Non-negativity restriction

(3) A nutritionist wants to design a breakfast menu for hospital patients. The menu is to include two items A and B. The number of units of iron and vitamin D contained in A and B are given below.

<table>
<thead>
<tr>
<th></th>
<th>Iron</th>
<th>Vitamins</th>
<th>Cost /ounce(Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

In the breakfast must contain 8 units of iron and 10 units of vitamin D, how many ounce of each item should be provided in order to meet the the iron and vitamin D in minimum cost?

**Solution:**

Now, we will discuss only the formulation part of this problem:

Let, \( x \) = Ounce of item A
\[ y = \text{Ounce of item B} \]

**Constraints:**

<table>
<thead>
<tr>
<th></th>
<th>Iron</th>
<th>Vitamin D</th>
<th>Costs(Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item A (x)</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Item B (y)</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Not less than

<table>
<thead>
<tr>
<th></th>
<th>Iron</th>
<th>Vitamin D</th>
<th>Costs(Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not less than</td>
<td>8</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Now, we can write the problem as follow:

Minimise  
\[ C = 2x + 3y \]  
Objective function

Subject to

\[ x + 2y \geq 8 \]  
Iron constraints

\[ 2x + 2y \geq 10 \]  
Vitamin D constraints

\[ x \geq 0, y \geq 0 \]  
Non-negativity restriction
Key to formulation:

1. What variables or unknown are involved?
2. What quantity is to be maximised or minimized and how do I express that quantity in terms of my unknown? (The objective function)
3. What constraints do I have? How can I express those constraints in terms of my unknown? (In LPP, this results in a set of linear inequalities) (The constraints)
4. Unknown variables of number 1 usually cannot have negative value. (Non-Negative Restriction), \( x \geq 0 \)

Mathematical symbols (relations) in terms of inequalities:

<table>
<thead>
<tr>
<th>Mathematical terms</th>
<th>Symbol</th>
<th>Mathematical terms</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater (or more) than or equal to</td>
<td>( \geq )</td>
<td>less than or equal to</td>
<td>( \leq )</td>
</tr>
<tr>
<td>at least</td>
<td>( \geq )</td>
<td>utmost (at most)</td>
<td>( \leq )</td>
</tr>
<tr>
<td>Minimum of</td>
<td>( \geq )</td>
<td>up to</td>
<td>( \leq )</td>
</tr>
<tr>
<td>not less than</td>
<td>( \geq )</td>
<td>maximum of</td>
<td>( \leq )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>not more than</td>
<td>( \leq )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>limited to</td>
<td>( \leq )</td>
</tr>
</tbody>
</table>

SOLVING LP PROBLEM BY GRAPHICAL METHOD:

Steps:
1. Express all the constraints from inequality to equality form.
2. Draw the graph of each equation in two dimensional planes.
3. Get the solution set of each constraint.
4. Determine the feasible region.
5. Obtain the vertices of the feasible region which are the intersection of the boundary lines.
6. Find the values of the objective function at each vertex. Get the maximum or minimum value as asked in the question.

Maximise

\[ Z = 12x + 15y \]

Objective function

Subject to

\[ 12x + 4y \leq 48 \] \hspace{1cm} Species A constraints
\[ 6x + 14y \leq 72 \] \hspace{1cm} Species B constraints
\[ 14x + 12y \leq 84 \] \hspace{1cm} Species C constraints
\[ x \geq 0, y \geq 0 \] \hspace{1cm} Non-negativity restriction

BY NP Upadhyaya
x = units of swan timber to be produced  
y = units of fuel woods to be produced  

(EOF, 2060)

Step 1  
Changing the inequality into equality form

<table>
<thead>
<tr>
<th>First constraint</th>
<th>Second constraint</th>
<th>Third constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>12x + 4y = 48</td>
<td>6x + 14y = 72</td>
<td>14x + 12y = 84</td>
</tr>
<tr>
<td>x = 0, y = 12</td>
<td>x = 0, y = 5.14</td>
<td>x = 0, y = 7</td>
</tr>
<tr>
<td>x = 4, y = 0</td>
<td>x = 12, y = 0</td>
<td>x = 6, y = 0</td>
</tr>
</tbody>
</table>

For Point B
6x + 14y = 72---2  
14x + 12y = 84---3  
Or,  
42x + 98y = 504  
42x + 36y = 252  
Hence, y = 252/62  
= 126/31  
Putting the value of y in equation 3  
x = 78/31

For Point C
14x + 12y = 84---3  
12x + 4y = 48-----1  
Or,  
14x + 12y = 84  
36x + 12y = 144  
Hence, x =  
= 30/11  
Putting the value of x in equation 1  
y = 42/11
Step 2
Draw the graph.

![Graph showing the feasible region and points O, A, B, and C with the equations 12x + 4y = 48, 4x + 12y = 84, and 6x + 14y = 72. Points O (0, 0), A (0, 5.14), B (4, 2), and C (6, 0) are marked.

<table>
<thead>
<tr>
<th>Points</th>
<th>Value of Z = 12x + 15y</th>
<th>Calculated values</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>0 0</td>
<td>12 × 0 + 15 × 0</td>
</tr>
<tr>
<td>A</td>
<td>0 5.14</td>
<td>12 × 0 + 15 × 5.14</td>
</tr>
</tbody>
</table>
Minimisation type Problem:
Minimise

\[ C = 50x + 40y \]

Subject to

\[ 6x + 3y \geq 30 \]
\[ 3x + 3y \geq 18 \]
\[ x \geq 0, y \geq 0 \]

Non-negativity restriction

IOF, 2067

Converting inequality into equation:

<table>
<thead>
<tr>
<th>First constraint</th>
<th>second constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>6x +3y =30</td>
<td>3x + 3y = 18</td>
</tr>
<tr>
<td>x = 0</td>
<td>x = 6</td>
</tr>
<tr>
<td>y = 10</td>
<td>y = 0</td>
</tr>
</tbody>
</table>

Drawing the graph we get,

For Point B:
\[ 6x + 3y = 30 \] .................. 1
\[ 3x + 3y = 18 \] .................. 2
\[ 3x = 12 \]
Therefore, \( x = 4 \)

Putting the value of \( x \) in eq. 1 we get
\[ 3y = 30 -24 = 6 \]
Therefore, \( y = 2 \)

Results: at point B optimal solution is obtained.
In order to maximise profit following product mix should be produced.

Sawn timber: 2.52 units (x)
Fuel woods: 4.06 units. (y)
Calculating the objective function value:

<table>
<thead>
<tr>
<th>Points</th>
<th>x</th>
<th>y</th>
<th>Objective function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>10</td>
<td>$50x + 40y$</td>
<td>400</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>2</td>
<td>$50 \times 4 + 40 \times 2$</td>
<td>280</td>
</tr>
<tr>
<td>C</td>
<td>6</td>
<td>0</td>
<td>$50 \times 6 + 40 \times 0$</td>
<td>300</td>
</tr>
</tbody>
</table>

Results:
In point B minimum value 280 is obtained.
Optimal solution is, $x = 4$ and $y = 2$.

Do the Following problem. (LPP Formulation part only)

1. A furniture manufacturing firm produces two goods chairs and tables. The profit per chair is Rs 10 and Rs 7 respectively. A table takes four hours of carpentry and three hours of panting, while a chair requires two hours of carpentry and three hours of panting. The total numbers of hours available for carpentry and panting is 300 and 210 respectively. The firm intends to maximize its profit. Using simplex method find out the optimal solution. *(IOF,2059)*

2. A furniture manufacturing firm produces two goods tables and chairs with two inputs sal and sissoo. The total quantity of input sal and sissoo to the firm may be specified as sal = 1600 units and Sissoo = 2000 units. Let us assume that producing one unit of table requires 4 units of Sal and 2 units of Sissoo and one unit of chair requires 2 units of Sal and 5 units of Sissoo. Profit per unit of table and chair are estimated as Rs 10 and Rs 8 respectively. The firm intends to maximise its profit. Calculate Using Simplex method of linear programming the output mix of tables and chairs that can yield maximum profit.
Discuss the role of linear programming in sensitivity analysis of the firm like this. (IOF, 2058)

3. A furniture manufacturing firm produces two goods chairs and table. The profit per table and chair is Rs 12 and 8 respectively. A table takes four hours of carpentry and three hours of panting, while a chair requires two hours of carpentry and three hours of panting. The total numbers of hours available for carpentry and panting is 340 and 220 respectively. The firm intends to maximize its profit. Using simplex method find optimal solution. (IOF, 2062)

4. In Pokhara, a firm produces Swan Timber and Fuel-wood at given prices of Rs 12 and Rs 15 respectively for each unit. To produce Swan timber, the firm requires 12 units of species A, 6 units of species B and 14 units of species C. Fuel-wood requires 4 units of species A, 14 units of species B and 12 units of species C. Total available inputs in each cases are 48 units of A, 72 units of B and 84 units of C. Using simplex Methods of Linear programming, find out the two products combination to be produced by the firm to earn the Maximum revenue. Discuss the assumption upon which the linear programming is based. (IOF, 2060)

5. A firm produces two types of table: A and B. The profit on each table of type A is Rs 10 and on each table of type B is Rs 12. The time required for carpentry and panting of type A are 4 and 3 hours respectively where as time required for above two process of type B are respectively 3 hours and 4 hours. If the total time available for carpentry is 24 hours and for panting is 18 hours. Find the combination of two types of tables to maximize profit using graphical method of linear programming. (IOF, 2056)

6. A carpenter has 90, 80 and 50 running feet respectively of teak, plywood and rosewood. The product A requires 2, 1 and 1 running feet and the product B requires 1, 2 and 1 running feet of teak, plywood and rosewood respectively. If A would sell for Rs 48 and B for Rs 40 per unit, how much of each should he make and sell in order to obtain maximum gross income out of his stock of wood? (CA, CAPII, 2067)

7. Institute of Agriculture and Animal science Rampur, Chitawn suggested to a farmer to spread out at least 4800 kg of a special phosphate fertilizer and not less than 7200 kg of a special nitrogen fertilizer to raise productivity of corps in his fields. There are two sources of obtaining these— mixture A and B. Both of these are available in bags weighing 100 kg each and they cost Rs 40 and 24 respectively. Mixture A contains phosphate and Nitrogen equivalent of 20 kg and 80 kg respectively, while mixture B contains these ingredients equivalent of 50 kg each. Write this as a linear programming problem and determine how many bags of each type the farmer should buy in order to obtain the required fertilizer at minimum cost.

8. A 24- hours supermarket has the following minimal requirements for cashiers:

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of day (24-hour clock)</td>
<td>03-07</td>
<td>07-11</td>
<td>11-15</td>
<td>15-19</td>
<td>19-23</td>
<td>23-03</td>
</tr>
<tr>
<td>Minimum number required</td>
<td>7</td>
<td>20</td>
<td>14</td>
<td>20</td>
<td>10</td>
<td>5</td>
</tr>
</tbody>
</table>

Period 1 follows immediately after period 6. A cashier works eight consecutive hours, starting at the beginning of one of the six time periods. Determine a daily employee worksheet which satisfies the requirements with the least number of personnel. Formulate the problem as a linear programming problem.
Simplex Method:
Although graphical method is very efficient in developing the conceptual framework necessary for fully understanding the linear programming process, it suffers from the great limitation that it can be applied only two decisions variables. In the real-world situations, we frequently encounter cases where more than two variables are involved and, therefore, look for a method that handled them. The simplex method provides an efficient technique which can be applied for solving LPPs of any magnitude involving two or more decision variables.

The simplex algorithm is an iterative procedure for finding, in a systematic manner, the optimal solution to a linear programming problem.

: Conditions for application:
1. The RHS of each of the constraints, $b_i$, should be non-negative. If an LPP has a constraint for which a negative resource value is given, it should be in the first step, converted into positive value by multiplying both sides of the constraint by -1. For example, if the given constraint is;
   \[ 8X_1 - 3X_2 \geq -6 \]
   It shall change into;
   \[ -8X_1 + 3X_2 \leq 6 \]
   Notice that the direction of inequality changes in the process.
2. Each of the decision variables of the problem should be non-negative. Sometimes a problem might have a variable which is unrestricted in sign or free so that it can assume negative values as well as non-negative. This situation is handled by treating such a variable as the difference of two variables which are both non-negative, because such a difference may be positive, negative or zero.

Solving Methods:

1. Maximization problem:
Maximize,
\[ Z = 40X_1 + 35X_2 \]
Subject to,
\[ 2X_1 + 3X_2 \leq 60 \]
\[ 4X_1 + 3X_2 \leq 96 \]
\[ X_1, X_2 \geq 0 \]

After introducing necessary slack variables the problems become;
Maximize,
\[ Z = 40X_1 + 35X_2 + 0S_1 + 0S_2 \]
Subject to,
\[ 2X_1 + 3X_2 + S_1 + 0S_2 = 60 \]
Further step see given solved problems.

2. **Minimization problems:**

Minimize,

\[ Z = 40X_1 + 24X_2 \]

Subject to,

\[
\begin{align*}
20X_1 + 50X_2 & \geq 4800 \\
80X_1 + 50X_2 & \geq 7200 \\
X_1, X_2 & \geq 0
\end{align*}
\]

After introducing necessary surplus and artificial variables the problems become;

Minimize,

\[ Z = 40X_1 + 24X_2 + 0S_1 + 0S_2 + MA_1 + MA_2 \]

Subject to,

\[
\begin{align*}
20X_1 + 50X_2 - S_1 + 0S_2 + A_1 + 0A_2 & = 4800 \\
80X_1 + 50X_2 + 0S_1 - S_2 + 0A_1 + A_2 & = 7200 \\
X_1, X_2, S_1, S_2, A_1, A_2 & \geq 0
\end{align*}
\]

Further step see given solved problems.

**Converting to the duel:**

1. If the primal problem is of the maximization type, the duel problem is of minimization type.
2. The constraint values of the primal problem have become the coefficients of the duel variables in the objective function of the duel and the coefficients of the variables in the objective function of the primal have become the constraint values in the duel.
3. The first column of the coefficients in the constraints in the primal has become the first row in the constraints in the duel, and the second column has similarly become the second row and so on.
4. The direction of inequalities in the duel is the reverse of that in the primal.
5. Decision variables are as usual. (no direction change)

**: Revision summary:**

1. **Testing the optimality:**
   When an artificial variable is eliminated in the basis, a simplex tableau depicts an optimal solution if all entries in the \( \Delta_j \) row are;
   a. Zero or negative when the LPP is of maximization type.
   b. Zero or positive when the LPP is of minimization type.

2. **Deriving a revised tableau for improved solution:**
   a. calculation of \( z_j \):
To obtain the value of $z_j$ under each variable head column, first each element of that column is multiplied by the corresponding coefficient of the solution variables appearing in the basis. Then the product is added up and we get $z_j$.

b. Key column:
- The variable that has largest positive $\Delta_j$ value. (Maximization problem)
- The variable that has the most negative $\Delta_j$ value. (Minimization problem)
- The variable of the key column is the incoming variable.

c. Key row:
The $b_i$ values are divided by the corresponding values in the key column and we get the ratio:

$$\frac{b_i}{a_{ij}}$$

It is called the replacement ratio. The row with the least non-negative quotient is called the key row and the variable corresponding to this represents the outgoing variables.

d. Key element:
The element which lies at the intersection of the key column and key row is termed as the key element.

e. Replacement row:
The row of the new tableau which is obtained by dividing each element of key row, including $b_i$ of the old tableau by the key element is called the replacement row.

f. For each row (of new tableau) other than replacement row:

$$\text{New row element} = \text{old row element} - \left( \text{row element in the key column} \times \text{corresponding replacement row values} \right)$$

2.5 Management planning for the firm:

A firm is defined to be the unit that employs factors of production to produce commodities that is sells other firms, to households or the central authorities. The term producer and firm are used interchangeably. Hence the firm is an organization which changes hired inputs into saleable outputs. The inputs or the factors of production are divisible into two broad categories human resources and capital resources. Labour resources and entrepreneurial resources are the two human resource input while land, man-made capital, forest, rivers etc are the capital resources. In economics the four major factors of production and land, labour, capital (man-made) and entrepreneurial (organisation) and the remuneration they get as wage, rent, interest, and profit respectively.

Systematic arrangement and working of all inputs in order to achieving the goal of the firm is simply termed as management planning for the firm. Planning is the fundamental to the management process, because if focus the basis from which all other management action take place. Planning is oriented to the future. It implies a thorough understanding of the goals of the particular business firm involved. It requires intellectual effort, reflective thinking, foresight and imagination. A planner must visualize the working or, of proposed set of activities.

Planning is a dynamic function. All plans are tentative and subject to change. A good manager will continually reassess a plan and modified it if needed. The timing aspect of planning is
critical. There must be a proper time to implement a plan. Effective planning involves answering many questions. Necessarily the planning is deeply involved in policy making and its implementation.

Planning is the job of management. It is the responsibility of management executives to consider short-run plan, long-run plan, growth plans, plans for new product development including resource and development and means of getting the most from both the firm's resources and external resources of information.

Steps for planning:
- Situation analysis:
- Organisation for planning:
- Programme planning process:
- Planed programme:
- Plan of work:
- Execution of plan of work:
- Appraisal of accomplishment:

2.5.1 Forecasting parameters of a firm (input-output and product)

Forecasting Concepts:
- A forecast is an estimation of the future level of some variables based on the knowledge gained from the analysis of time series data.
- Forecasting deals with the process of making definite estimates of the future conditions on a systematic basis.
- The result obtained in forecasting process known as forecast.
- "Base point" is the point of time when the forecast is made.
- "Forecast point" is the point of time which forecast relates.
- The interval between the base point and the forecast point is described as the range of forecast.
- Most firms forecast in order to help the firm in strategic planning activities such as inventory purchasing, capacity planning, yield regulating, harvest planning etc.

Basic idea about input- output and product level:
- Any output necessary for a particular firm is determined by output level.
- Output may be qualitative or quantitative.
- Any product of a firm is collectively said as output.
- Output may be as physical products form or service form, depending upon the firm's nature.
- Manufacturing firms produces physical products, which are easy to objectively define.
- Non-manufacturing firm produces service oriented products.
- Forest related firm may produce both types of products.
- How many or much product a firm should be produced, eventually depends on consumer demand.

Parameter:
Anything else is related to with anything else, and such a relation is determined by the parameter estimate. Parameters are the something that that decide or limit the way in which something can be done. Parameter is a quantity which remains constant in a given context. Thus for, instance, in the equation, 

\[ Y = a + bX \]

Where, \( Y \) and \( X \) are variables, and \( a \) and \( b \) are constants, \( a \) and \( b \) are the parameters of the equation.

**Forecasting technique: (consumer demand)**

### Exponential smoothing:

\[ F_{t+1} = \alpha y_t + \alpha(1 - \alpha)y_{t-1} + \alpha(1 - \alpha)^2y_{t-2} + \alpha(1 - \alpha)^3y_{t-3} \ldots \]

Where, 
\( t \) is the time period and \( 0 \leq \alpha \leq 1; \) \( \alpha \) is called the smoothing constant.

**Key points:**
- Forecasting is a vital aid to managerial decision making.
- Broadly, forecast can be made by using qualitative method, using judgment, or by quantitative methods using numerical information.
Quantitative techniques comprise time series models, where the historical data are used for making forecast and causal models in which forecasts of a variable are made on the basis of the value of the other variable or variables to which it is related.

Time series models include (a) moving average, where each period's forecast is obtained as the simple, or weighted mean of the actual values for the immediately preceding "n" periods; (b) exponential smoothing, where a forecast is obtained as the weighted average of the values of all the preceding periods and (c) trend projection, in which the past trend is projected into future to make the forecast.

Regression analysis represents a causal technique to make forecast. In a one independent variable case a regression line is fitted to the given pairs of the data points, of which is drawn on the principle of least squares. Once the slope and Y–intercept of the line are obtained, forecast can be made by substituting known values of the independent variables. In multiple regressions also, The Y–intercept and the partial regression coefficient are obtained similarly as in case of the simple regression analysis. The standard error of estimate represents the overall accuracy of the forecasts in each case.

2.5.2 Planning method for a firm:

Firm is the basic unit of decision taking in a decentralize economy. The theory of the firm models, how a firm would behave given assumptions about its objective, which may include profit maximization, avoidance of risk and long-run growth. Many firms are run by sole traders, and others are partnership; larger firms are usually organized as companies.

- Sole traders (Proprietorship): The enterprise is owned and controlled by one person. Firm has unlimited liability and limited life.
- Partnership: The persons who own the partnership business are individually called 'partners' and collectively they are called firm. Partnership is an association of two or more persons who have agreed to share the profits of a business which they run together. Firm has unlimited liability and limited life.
- Company: Limited liability for the owners and perpetual life for the business. A company is a artificial person being created by the law that has an existence separate and apart from its owners. Private company has 2 to 50 members and public company has at least seven and more members. (Company act, 2063 section 9)

How to planning?

a. Objective:

b. Ownership- sole traders, partnership or company.

c. Capital budgeting (Long term investment decision): This is essentially a process of conceiving, generating, evaluating and selecting the most profitable projects for investing the funds available to the firm.

1. Prerequisites of capital budgeting.
2. Demand for capital.
3. Investment criteria and decision.
   • Payback period (or payout period)
   • Net discounted present value (NPV).
   • Internal rate of return (IRR) or marginal efficiency of investment.
UNIT: 3 MARKETING FOR FOREST PRODUCT

3.1 Determinants of demand for forest product:
Economic analysis has recognized the role of key variables in determining demand and consumption. In practice, the distinction between demand (as a schedule of quantities as a function of price, other factors held constant) and consumption as an equilibrium quantity at a given price is frequently ignored. The development of "gap" type models illustrate the common approach of projecting 'demand' as a fixed quantity independent of price.

Demand, as the relationship between price and quantity, is subject to change over time due to changes in the underlying factors held constant by the static notion of demand. Changes in demand "shifters" are often included in economic estimation of demand representing anticipated dynamics in these determinants.

Levels of income:

A key determinant of demand is the level of income evident in the appropriate country or region under analysis. As a generality, the higher the level of aggregate and/or personal income the higher will be the demand for a typical commodity, including forest products. More of a good or service will be chosen at a given price where income is higher. Thus determinants of demand normally utilize some form of income measure, including Gross Domestic Product (GDP).

Population:

Population is of course a key determinant of demand. Although all forest products do not necessarily enter final consumer markets, the actual markets are largely presumed to be functionally related to population. Growing populations are positively correlated to timber demands in the aggregate, as well as specifically to individual forest products. Frequently,
population and income estimators are combined, as in the case of the use of Gross Domestic Product per capita.

**End market indicators:**

The use of end market indicators as determinants of demand is frequently incorporated into demand analysis. For example, much of the final use of forest products is linked to construction (residential and total). Indicators and trends related to construction activities, or which are determinants of construction, provide indirect estimates of the influence of these activities as the source of derived demand for wood. Housing starts, public investments, interest rates, etc. can be highly correlated to timber demand.

**Availability and price of substitute goods:**

Consumption choices related to timber are also influenced by the alternative options facing users in the relevant marketplace. The availability of potential substitute products, and their prices, weighs heavily in determining the elasticity of demand, both in the short run (static) sense and over time (long run). Fuelwood, as a dominant use of timber in the Asia Pacific Region, reflects conditions of very limited options for energy sources at 'reasonable' prices. Rural low income or subsistence populations simply do not have 'options' regarding energy - they use wood or go without. Demand, at this basic level, in almost is perfectly inelastic. The cost (if only implicit in terms of gathering time) does not materially affect consumption quantity.

Suitability of alternative goods and services is, in part, a question of knowledge as well as availability. Market information regarding alternative products, quality, convenience, and dependability all influence choices. Under conditions of increased scarcity and rising prices for tropical hardwood panels, for example, users have a positive incentive to search for and investigate the suitability of alternatives that were previously overlooked or ignored.

**Tastes and preferences:**

All markets are shaped by collective and individual tastes and preferences. These patterns are partly shaped by culture and partly implanted by information and knowledge of products and services (including the influence of advertising). Different societies use forest products differently because of these differences in taste and preferences. For example, markets for wood products in Japan are commonly recognized as requiring very high product quality standards, the importance of visual attributes of wood, and other preferences not commonly found in many other markets.

**Key points:**

- Obviously, the quantity of timber consumed represents both what is demanded and what is supplied at a prevailing price under current or projected conditions.
- National as well as international pricing policy about forest product (basically timber) also affects the demand conditions.
• Introducing the tax as well as subsidies also affect the forest product demand considerably.
• In case of forest recreation availability of leisure time may be a component of recreational demand determinant.

3.2 Measuring elasticity of forest product demand:

Given a demand curve, there will be some quantitative response in the quantity sold if its determinant is changed. Such type of phenomena can be explained by elasticity concept. There are mainly three type of elasticity concept in use.

1. Price elasticity:
   - Useful in describing the demand relationship and its implication with respect to price-quantity, revenue relationship.
   - Movement along the demand curve.

\[
E_p = \frac{\% \text{ change in quantity}}{\% \text{ change in price}}
\]

\[
E_p = \frac{\Delta Q}{\Delta P} \times \frac{P}{Q}
\]

Where,
\(\Delta Q = \text{Change in quantity.}\)
\(\Delta P = \text{Change in price}\)
\(P = \text{Initial Price.}\)
\(Q = \text{Initial Quantity}\)

Since demand curves are almost always negatively sloped it follows that price elasticity will normally be negative. In practice, however, the sign is usually ignored and elasticity is said to vary zero to infinity. If \(E_p\) is less than one the curve is described as being inelastic, and if zero it is called perfectly inelastic. If elasticity is greater than one , the demand is termed elastic, and \(E_p\) tends toward to an infinite value the curve is said to be perfectly (or infinitely) elastic. The special case of \(E_p = 1\) is termed unit elasticity.

Calculation of arc elasticity:

Calculation of 'arc elasticity' such as this reveals a particular difficulty, for clearly, the percentage change might be based on either the beginning or ending values. To eliminate this problem it is usual to make the average of the two prices and quantities the bases for the percentage calculations. Consequently, arc elasticity becomes an "average" elasticity between two selected points.
Elasticity at a point:
A more precise measure is obtained by permitting P and Q to tend to zero, and treating elasticity as a point concept, \( \frac{\Delta Q}{\Delta P} \) then becomes, \( \frac{dQ}{dP} \), or the reciprocal of the slope. Hence, to calculate elasticity of demand with respect to price at any point on the demand curve one can simply multiply the reciprocal of the slope of the curve by the ratio \( \frac{P}{Q} \), using this value of P and Q the slope as the desired point. Eventually relation can be expressed as;

\[
E_p = \frac{\text{Lower Segment of the curve}}{\text{Upper segment of the curve}}
\]
Elasticity and revenue:

<table>
<thead>
<tr>
<th>Relation</th>
<th>Effect on revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Price rises</td>
</tr>
<tr>
<td></td>
<td>Price falls</td>
</tr>
<tr>
<td>Unit elasticity</td>
<td>No change</td>
</tr>
<tr>
<td>Elastic</td>
<td>Revenue falls</td>
</tr>
<tr>
<td>Inelastic</td>
<td>Revenue rises</td>
</tr>
<tr>
<td></td>
<td>Revenue falls</td>
</tr>
</tbody>
</table>

2. Income elasticity:

A change in any variable other than price implies a shift of the demand curve rather than a movement along the curve itself. Any variable other than price may be income. To describe the relationship between incomes and demand the term income elasticity is used.

\[
Income\ elasticity = \frac{\% \text{ change in quantity demanded}}{\% \text{ change in incomes}}
\]

Eventually the relation may be expressed as;

\[
Income\ elasticity = \frac{\% \text{ change in quantity consumed}}{\% \text{ change in incomes}}
\]

3. Cross elasticity:

Cross elasticity is another term that may be encountered in forest economics. It may be defined as;

\[
E_{xy}^x = \frac{\% \text{ change in quantity of product } X}{\% \text{ change in price of product } Y}
\]

3.3 Derived demand by a firm:

The demand for a factor of production is said to be a derived demand. This is because both the intensity of demand and the relationship between factor price and quantity demanded are determined by the demand for the final products. The greater the demand for the finished products will be, the greater the demand for the factor of production and vice-versa.
We know that the demand for most timber, paper and plywood is not direct but is derived from the sale or the expected sale of finished house, furniture, or of newspapers, magazines, books, or of the hundreds of other things into which these products are fabricated.

Demand may be distinguished as autonomous and derived demand. Autonomous demand for a commodity is one that arises independent of the demand for any other commodity whereas derived demand is one that is tied to the demand for some 'parent product'. The demand for a commodity which arises directly from the biological or physical needs of the human beings may be considered as autonomous demand, e.g. demand for food, clothes, shelter etc. On the other hand, demand for a commodity that arises because of the demand for some other commodity may be considered as derived demand.

- Demand for land, fertilizers, and agricultural tools and implements are derived demand because they are dependent on or tied with the demand for food.
- Demand for cotton, bricks, cement, wood etc are derived demand.
- Demand for producers' goods or firms' goods or industrial inputs are derived demand.
- Demand for complementary commodities which complement the use of other commodities, or for supplementary commodities which supplement or provides additional utility from the use of other goods is a derived demand.
- For instance, power regulator is complementary goods of a refrigerators and TV sets, and a chair is a complement and table glass is supplement to the use of table. Therefore demand for power regulator, chair, and table glass would be considered as derived demand.

The conceptual distinction between autonomous demand (ie demand for parent product) and derived demand would be useful for firms' point of view to the extent the former can serve as an indicator of the latter.

The demand for many of the major forest products is derived demand. For example, that for timber, plywood, pulp, many kinds of industrial paper etc. The demand for tissue paper, writing paper, firewood etc in contrast is direct demand. The demand for most of the product of a forest firm, ie the demand for standing wood or wood in the firm of logs, is derived demand. Therefore it is necessary to see how a derived demand is obtained.

Instead of starting with consumer's utility function we start with the production function of the firm which demands the commodity. Let it be, \( Q = f(X_1, X_2) \)
where, \( Q \) is the quantity of the output of the finally consumed commodity produced by the firm per unit of time, and \( X_1, X_2 \) are the quantities of the two (only two in this case) inputs required in the production process;
Let us suppose that the prices of the produced commodity and the two inputs are constant over the relevant range and are denoted by \( P, P_1, P_2 \) respectively and the profit made by the firm is \( M \) rupees, now

\[
M = PQ - P_1 X_1 - P_2 X_2
\]
From this equation, eventually we can obtain the derived demand functions for the two products.
3.4 Measuring demand for non-market goods:

Classification of goods:

<table>
<thead>
<tr>
<th>SN</th>
<th>characteristics of the good</th>
<th>Exclusive property right</th>
<th>Non-exclusive property right</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Rivalry in use</td>
<td>Private goods</td>
<td>Common property resources.</td>
</tr>
</tbody>
</table>

Common property resources to some extent and pure public goods are generally non-marketed goods.

Some goods and services like recreational fishing and wildlife viewing are not traded in a well functioning, traditional market. That is, they are not supplied by private firms and consumers do not pay market prices. Nonetheless, individuals benefit from their use and, therefore, the loss of such environmentally related goods signifies welfare losses to these individuals. Conceptually, the same measure of benefit applies to market and non-market goods, that is, the maximum amount an individual would pay to avoid losing, or gaining, access to the good. Since these are non-market benefits, typically, there is no producer, or the consumer is both the producer and consumer. Thus, measures of non-market benefits are concerned with estimates of consumer demand and consumer surplus. There are a variety of methods that have been developed to measure this value concept in the absence of markets.

Basically there are two basic approaches measuring demand for non market goods:

1. Revealed preference:
2. Stated preference:

**Revealed preference:**

In revealed preference, we observe a real choice in some market and cleverly infer information on the trade-off between money and the non market good. For instance, we may notice that two commodities are identical except that one commodity has high housing prices and clean air and the other has lower housing prices and dirty air. We may infer that the difference in housing prices reflects the value people place on clean air, where clean air is non-market good.

**Stated preference:**

The second approach, stated preferences, basically involves asking people how much a non-market good is worth. Opinion polls and surveys are used to derive this information. This approach is controversial because of the absence of real choices.

**Indirect measurement of demand:**

Indirect techniques rely on observable behavior to deduce how much something is worth to an individual even though it is not traded in markets. These methods produce value estimates that are conceptually identical to market values, but they must be measured more creatively since market data are not available. Indirect techniques include travel cost models, random utility models, and the hedonic pricing method.
Direct measurement of demand:
By experimental method or contingent valuation which is based on direct survey, demand can be measured directly.

Non-Market Techniques for measuring demand:
In the absence of ownership and efficient pricing, we need special techniques to place consumer preferences for natural resources and environmental goods and services on common ground with the demands for more conventional commodities. Three types of procedures have been employed to measure these demands.

- Travel cost and random utility models, which are based on expenditures and travel behaviour for recreational opportunities.
- Hedonic pricing method is decomposing prices of market goods to extract embedded values for related environmental attributes.
- Experimental method is eliciting preferences, either by using hypothetical settings, called contingent valuation, or by constructing a market where none existed.

Travel cost models, random utility models, and hedonic methods are indirect measures based on observable behaviour (Revealed preference). Experimental methods, or contingent valuation, are based on direct surveys of individuals (Stated preference).

Measuring demand for forest product:

1. Survey Method:
Survey methods are generally adopted where estimating short term demand is involved. Under this method, surveys are conducted to collect information about the future purchase plans of the potential consumers.

Survey method includes:
   a. Survey of consumers' plan through direct interview of consumers:
      - What quantity of forest product they would be willing to buy at alternative prices over a given period say one year.
      - When all the consumers are interviewed, the method is known as complete enumeration survey method or as comprehensive interview method.
      - When only a few selected representative consumers are interviewed, it is known as sample survey method.

   b. Opinion survey method (Opinion pool method):
This method is to collect the opinion of those who have the feeling of the market, like sales representatives, professional exports, market consultants, etc, instead of contracting the consumer themselves.

2. Market studies and experiment:

Under this method forest product producing firms first select some areas of the representative markets, say three or four cities, having similar characteristics, such as population, income levels, cultural and social background, occupational distribution, choice and preference of consumers. Then they carry out market experiments by changing prices, advertisement
expenditure, and other controllable variables in the demand function under the assumption that other things remain the same. The variable may be changed over time either simultaneously in all the markets or in the selected markets. After such changes are introduced in the market, the consequent changes in the demand over a period of time (Say a week, a fortnight, a month) are recorded. On the basis of data collected elasticity coefficients are calculated. These coefficients are then used along with the variables of demand function to assess the demand for the product.

3 **Statistical method:**
Statistical method utilizes historical (Time-series) and cross-section data for estimating long-run demand. The statistical methods which are frequently used for making demand projections are
- Trend projection method
- Regression method
- Leading indicator method or barometric method

Trend projection method:
- Firms collect time-series data from their own sales department.
- These data can be used to project the demand for a product for future in two ways; graphical method and least square method.

Regression method:
- The first step in regression analysis is to specify the variables that are supposed to affect the demand for product in question. These variables are treated as independent variables.
- The second step is collection of time series data on the independent variables.
- The third step is to specify the form of equation which can appropriately describe the nature and extent of relationship between the dependent and independent variables.
- The fourth or final step is to estimate the parameters in the chosen equation with the help of statistical techniques.

Leading indicator method or barometric method:

This method is based on the idea that the future demand can be predicted from certain events occurring in the present. This technique involves statistical indicators, usually time series, which when combined in certain ways provide indications of the direction of change in the demand. In this technique 3 series of demand indicators are suggested; leading series, coincidental series and lagging series.

3.5 **Approach to marketing (functional, institutional and commodity)**

Production is meant for consumption. Successful production is one that sells. But, before any product or service is offered for sale to market, several decisions need to be taken in regard to its marketing, for example;
- The price of product has to be determined.
- The method of marketing has to be identified.
- The channels of distribution have to be worked out.
All the phenomena are the approaches to marketing for a particular commodity as well as forest products as a whole. 

**According to Stanton** "Marketing is a total system of interacting business activities to plan, price, promote and distribute want satisfying products and services to present the potential consumer".

**Kotler opines**, "Marketing is a social and managerial process by which individual and groups obtain what they need and what through creating and exchanging products and values with others".

Generally there are following approaches to marketing of any commodity as well as forest products.

A. Functional approach.
B. Institutional approach.
C. Commodity approach.
D. Behavioural approach.
E. Managerial approach.

**A: Functional approach:**
The functional approach is one of the methods used in classification of activities that occur in the marketing processes by breaking down the processes into functions. A marketing function is defined as a major specialized activity performed in accomplishing the marketing process. Widely acceptable lists of marketing functions are

- Exchange function:
- Physical function:
- Facilitating function:

**1. Exchange function:**
Exchange functions are activities involved in the transfer of title to goods. They represent the point at which the study of price determination enters into the study of marketing. The main exchange functions are buying and selling. Both buying and selling functions have their primary objectives as the negotiation of favorable terms of exchange.

**Buying function**
This function is concerned with seeking out the sources of supply, assembling of products, and activities associated with purchase. It can be either the assembling the raw products from the production areas or the assembling of finished products into the hands of other middlemen in order to meet the demands of the ultimate consumer.

**Selling function**
It is more than merely passively accepting the price offered. It consists of various activities that are sometimes called merchandizing, physical arrangements of display of goods, advertising and other promotional devices to influence or create demand. It may also include the decision on the proper unit of sale, proper packages, best marketing channel and proper time and place to approach potential buyers.

**2: Physical functions**
Physical functions are those activities that involve handling, movement, and physical change of the actual commodity itself. They are involved in solving the problem of when, what and where in marketing. It is composed of storage, transportation and processing.

**Storage function**
It is concerned with making goods available at the desired time. It may be activities of elevators in holding large quantities of raw materials until they are needed for further processing. It may also be holding of supplies of finished goods as the inventories of processors, wholesalers or retailers.

**Transportation function**
It is concerned with making goods available at the proper place. It also includes the activities involved in preparation for shipment such as crating and loading. Adequate performance of this function requires weighing alternative routes and types of transportation as they might affect transportation costs.

**Processing function**
It includes all those manufacturing activities that change the basic form of the product, such as converting live animals into meat, fresh peas into canned or frozen peas, or wheat into flour and finally into bread. It is sometimes not included in the list of marketing functions because it is essentially form-changing activity.

3: **Facilitating functions**
Facilitating functions are those activities that make it possible for the smooth performance of the exchange and physical functions. These activities are not directly involved in either exchange of title or the physical handling of products. However, without facilitating functions modern marketing system would be impossible. They are sometimes called the grease that makes the wheels of the marketing machine go round. Facilitating functions include standardization, financing, risk bearing and market intelligence.

**Standardization function**
It is the establishment and maintenance of uniform measurements of both quality and quantity. It simplifies buying and selling, because it makes the sale by sample and description possible. It makes mass selling, which is so important to a complex economy, possible. Effective standardization is critical to efficient pricing process. Standardization also simplifies the concentration process, because it permits the grouping of similar lots of commodities early in movement from producing points. Policing of standards is crucial to ensure quality control in processing plants and inspections to maintain the standards in the marketing channel.

**Financing function**
It is the use of money to carry out various aspects of marketing. When there is storage or delay in the distribution of goods someone must finance the holding of goods. The holding period may be for one year or more, as in operations of the canning industries, or a relatively short time, as in
the marketing of perishables. Financing may take the obviously recognizable form of credit from various lending agencies or the more subtle form of tying up the owner’s capital resources. It is critical in modern marketing.

**Risk bearing function**

It is the accepting of the possibility of loss in the marketing of a product. Risks can be classified into two broad categories—physical risks and market risks. Physical risks are those that occur from destruction or deterioration of the product itself by fire, accident, wind, earthquakes, cold, and heat. Market risks are those that occur because of the changes in value of a product as it is marketed. Risk bearing may take a more conventional form, such as the use of insurance companies in the case of physical risks or the utilization of futures exchanges in the case of price risks. The entrepreneur himself may bear the risk without the aid of these specialized agencies. The function of risk bearing is often confused with the function of financing. Financing arises because of the time lag between the purchase and sale of products, whereas the need for risk bearing arises because of the possibility of loss during the holding period.

**Market intelligence function**

It is the job of collecting, interpreting and disseminating the large variety of data necessary to the smooth operation of the marketing processes. Market research to evaluate possible alternative marketing channels that may be used, the different ways of performing other functions, and the market potentialities for new products may be classified as part of the broad function of market intelligence. Efficient marketing cannot operate in an information vacuum. An effective pricing mechanism is dependent on well-informed buyers and sellers. Successful decisions on how much to pay for commodities or what kind of pricing policy to use in their sale require that a large amount of market knowledge be assembled for study. Adequate storage programs, an efficient transportation service, and an adequate standardization program all depend on good information. It may either be performed by those who specialize in its performance or by everyone in the market structure who buys and sells products.

There are three main characteristics of marketing functions. Firstly, the functions affect not only the cost of marketing, but also the value of products to consumers. Processing, transportation and storage provide form, space and time utility for consumers. The exchange and facilitating functions grease the wheel of the marketing machinery and perhaps provide services at lower costs than farmers and consumers can perform them. In evaluating marketing functions, consideration must be given to both costs and benefits of the functions.

Secondly, although it is frequently possible to “eliminate the middleman”, it is very difficult to eliminate marketing functions. Usually, eliminating the middleman involves the transfer of marketing functions—and costs—to someone else. For example farmers may assume the storage, selling and transportation functions, eliminating brokers and commission men. This reduces the cost of performing a marketing function, but does not eliminate the marketing function from the marketing process.

Thirdly, marketing functions can be performed by anyone anywhere in the marketing system. Conceivably, all the functions could be performed by a single firm which had complete control of a commodity from farm to the retail level. On the other hand, there are specialized firms and
industries such as railroads, grain brokers, and speculators- who perform only one marketing function.

**B: Institutional approach:**

Another method of market analysis is to study the various agencies and business structures which perform the marketing processes. Where the functional approach attempts to answer the “what” in the question “who does what,” the institutional approach to marketing problems focuses attention on the “who.” Marketing institutions are the wide variety of business organizations that have developed to operate the marketing machinery. The institutional approach considers the nature and character of various middlemen and related agencies and also the arrangement and organization of marketing machinery. In this approach the human element receives primary emphasis.

**Middlemen of marketing:**

Middlemen are those individuals or business concerns who specialize in performing the various marketing functions involved in the purchase and sale of goods as they are moved from producers to consumers. Our concern here is within the place in the marketing processes which the middlemen occupy. There is no limitation as to the way in which they are organized for doing business. They may operate as individual proprietors, partnerships, or cooperative or non-cooperative corporations. The middlemen of particular interest in forest products marketing can be classified as follows:

1. Merchant middlemen (Retailers, Wholesalers)
2. Agent middlemen (Brokers, Commission men)
3. Processors and manufacturers
4. Speculative middlemen
5. Facilitative organizations

**1. Merchant middlemen**

Merchant middlemen normally take title to, and therefore own, the product they handle. They buy and sell for their own gain and derive their income from the margins arising from the sales (i.e. difference between buying price and selling price). Unlike other classes of middlemen they hold uncertainty to a minimum i.e. know what the buying and selling price in going to be. They are not risk takers.

**Wholesalers:**

They are any merchant who does not sell to ultimate consumer in any significant amount. He therefore can sell to other wholesalers or to industrial users or retailers. Wholesalers make a highly heterogeneous group of varying sizes and characteristics. One of the more numerous groups of wholesalers are the local buyers or country assemblers who buy goods in producing areas directly from farmers and ship the products to the larger cities where they are sold to other wholesalers and processors. In this group are herbal plant buyer, cultivated land tree buyers.
Another group of wholesalers is located in the large urban centers. This may be full-line wholesalers who handle many different products or those who specialize in handling a limited number of products. They may be cash-and-carry wholesalers or service wholesalers who will extend credit and offer delivery and other services.

Retailers:

They are merchant middlemen who buy goods / services for resale directly to ultimate consumers. Represent the most numerous types of agencies involved in the marketing process. In terms of undertaking marketing functions their role in no easier compared to wholesalers. In fact a retailer may have to do all the functions of marketing i.e. his job is complex. Retailer is the producers’ representative to the consumer.

2 Agent middlemen

All agent middlemen of marketing don’t own what they handle i.e. not take title to the goods. They are agents/representatives of owners of goods and basically hired by their principals or clients. They derive their income from the fees they are paid by their clients or commissions given. Agent middlemen in reality sell services to their principals, not physical goods to customers. There are three categories of agent middlemen:

- Brokers
- Commission agents
- Auctioneers

Their main stock in trade is their knowledge of market in which they participate. They use the knowledge in bringing together potential sellers and buyers. Their services will be retained either by buyers or the seller who feels that he / she does not have knowledge or opportunity to bargain effectively for him / herself.

Commission Agents

The difference between brokers and commissions agents is one of degree to they are given power to handle the product that is being sold i.e. discretionary powers to assist their principals in ensuring that marketing process is a accomplished. Commission agents are given more discretionary powers over physical handling of the product, arrangement for terms of sale / purchase, collection of revenue from sale.

Brokers:

They are not given any physical control over the product. They ordinarily follow directions from their principals. Usually have little power over terms of sale or revenue collection. Bring seller and potential buyer together.

Auctioneers:
They do not own what is handled, may be involved in a number of activities. Have places for physical display, space where participants meet, announce the date of auction, facilitate in price formation. During the bidding process the main role of auctioneer is to announce the price offered by various participants such that it is heard and the highest bidder gets the good subject to the price being equal or greater than reserved minimum price. Prices closely conform to a competitive market price. In our country generally timber from the national forest are sold through auction.

3. Processors and manufactures

Their role in marketing is to undertake some action on the products in order to change their form. Form changing is basically a marketing service. Manufactures and processors may take active role in other institutional aspects of marketing e.g. may act as own buying agents in the producing areas, wholesaling of finished products and promotion. Processing and manufacturing are only part of activities they get involved in.

4. Speculative middlemen

They are those who take title to goods / products with a major purpose of profiting from price movement. They are specialized risk takers. They take uncertainty as given. Is the closest to the futures market usually speculative middlemen make purchase and sales at same marketing level e.g. buying timber and selling timber i.e. have no vertical integration. They are also called traders, scalpers and spreaders. Important distinguishing feature is that even thought speculative middlemen involve themselves in movement of goods that is not their goal. Speculative Middlemen are interested in short term price fluctuations. Speculators derive their income from short term price fluctuations in goods they handle. The emergence and growth of speculative Middlemen is due to the fact that merchant middlemen are not willing to engage themselves in added risk involved in purchasing and storing of goods for longer period of time. Speculative middlemen play important role in marketing process in ensuring that commodities are available from time to time. Their activities are desirable especially if their expectations are met / true. Due to their activities we may end up with more stable market prices.

5. Facilitative organizations

Main function into facilitate the activities of the other middlemen of marketing. Ensure that the activities take place in smooth manner. Does not directly participate in marketing process either as merchants, wholesalers etc. they basically establish the rules that the other participants have to follow. Others may get involved in establishing of the terms of sale and standards which must be followed, assist in grading of the produce, actual arrangement of payment for the transactions.

C. Commodity approach:

The commodity approach to marketing concentrates on a particular commodity such as "sal round timber" and follows it through its various processing stages as each market function is performed by each institutional organization. It combines institutional and functional approaches
in studying marketing of a single commodity. It helps focus attention on physical differences of commodities that contribute to different marketing costs. It is therefore more comprehensive when more details of single commodity marketing system are required since it tackles all issues relevant to the single commodity from supply point to the end user point.

Key concerns of commodity approach are:
- Source and conditions of supply.
- Storage, transportation and standardization.
- Demand conditions.
- Role of middlemen.

Relation to key concern:
- Source of supply may refer to geographical location of the commodity or different stages of marketing system.
- Condition of supply refers to the form of product which may either be in its raw or processed form.
- Storage refers to logistical, technical and economic considerations during the process of storing.
- Transportation and standardization refers to the process of ensuring requisite quantitative and qualitative standards are met as well as the physical movement of the commodity from point of purchase to point of sale.
- Demand refers to capture of the preference of the consumers of the commodity in its various form.
- Role of the middlemen is the different function of the middlemen regarding to the movement of the commodities from the point of purchase to the point of sale.

: End of this unit:

UNIT: 4 VALUATIONS OF FOREST AND RELATED NON-MARKET RESOURCES:

What is value?

The basic reason a good or service has value is because it does something that is desired by an individual or society. If provides a certain amount of utility. This utility may be from using the good or service for personal consumption, for example from eating a banana or going on a mountain flight. The utility may also be from earning money with which to purchase goods and services that in turn have utility.

The "demand value" of a good or service is what people would be willing to give up obtaining it. Demand value is based on the utility that the good or service will produce for the individual. It reflects the usefulness of the item to the person, in relation to that person's own tastes and preference and the alternative items available.

The demand curve or demand value reflects the usefulness of the good or services to the individual or society in monetary terms. It reflects the value of the consumption or use to those who use it.

The "supply value" of a good or service is what people who produce it require in order to sell it to someone else. It is the minimum price for which they will sell an item.
Characteristics of Economic Value:
- Products or services have value only if human beings value them, directly or indirectly.
- Value is measured in terms of trade-offs, and is therefore relative.
- Typically, money is used as a unit of account.
- To determine values for society as a whole, values are aggregated from individual values.

What is valuation?
Valuation is placing a value on something.

Main types of TEV measure:

Main TEV value measures fall into three categories:
- Direct market price:
- Indirect market price (value inferred from another market price) eg. residual values, value of production increases, surrogate price and replacement cost or cost avoided, opportunity cost, hedonic price and travel cost. (Revealed preference)
- Non-market prices (Stated preference)

Common valuation Method:

<table>
<thead>
<tr>
<th>1. Market price method:</th>
<th>Estimates economic values for ecosystem products or services that are bought and sold in commercial markets.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Productivity method:</td>
<td>Estimates economic values for ecosystem products or services that contribute to the production of commercially marketed goods.</td>
</tr>
<tr>
<td>3. Hedonic pricing method:</td>
<td>Estimates economic values for ecosystem or environmental services that directly affect market prices of some other good. Most commonly applied to variations in housing prices that reflect the value of local environmental attributes.</td>
</tr>
<tr>
<td>4. Travel cost method:</td>
<td>Estimates economic values associated with ecosystems or sites that are used for recreation. Assumes that the value of a site is reflected in how much people are willing to pay to travel to visit the site.</td>
</tr>
<tr>
<td>5. Damage cost avoided, replacement cost, and substitute cost method:</td>
<td>Estimate economic values based on costs of avoided damages resulting from lost ecosystem services, costs of replacing ecosystem services, or costs of providing substitute services.</td>
</tr>
<tr>
<td>6. Contingent valuation method:</td>
<td>Estimates economic values for virtually any ecosystem or environmental service. The most widely used method for estimating non-use, or “passive use” values. Asks people to directly state their willingness to pay for specific environmental services, based on a hypothetical scenario.</td>
</tr>
<tr>
<td>7. Contingent choice method</td>
<td>Estimates economic values for virtually any ecosystem or environmental service. Based on asking people to make tradeoffs among sets of ecosystem or environmental services</td>
</tr>
</tbody>
</table>
or characteristics. Does not directly ask for willingness to pay-this is inferred from tradeoffs that include cost as an attribute.

| 8. Benefit transfer method: | Estimates economic values by transferring existing benefit estimates from studies already completed for another location or issue. |

Forest valuation:

Forest valuation is the placing of a value on forest production. Defining forest production provides no conceptual problem. The familiar wood, water, range, wildlife, and recreation are included. Esthetic values and vicarious use by urban dwellers might also be added to the list. This first list can then be further divided. For, example, recreation can be divided into campground and wilderness recreation, and wilderness recreation can be divided still further into wilderness hiking and wilderness rafting.

Why forest valuation?

- To reach better estimate of all goods and services provided by a forest.
- To reinstate appreciation of forests, as a valuable economic, ecological and social asset, and
- To provide estimated values even though they may not all be captured.

Classification of forest value:

(Adapted from Gregersen et al, 1995)

I. Use values

A. Direct use values (Associated with the following benefits)

A.1 Consumptive uses:

A.1.1 they are Commercial/industrial market goods (Fuelwood, timber, pulpwood, poles, fruits, animals, fodder, medicines, commercial non-wood products (eg rattan) etc.)
A.1.2 they are indigenous non-market goods and services (Fuelwood, non-commercial non-wood products, animals, skins, poles, fruits, nuts, medicinal plants etc), food security.

A.2 Non-consumptive uses:

A.2.1 Recreation (jungle cruises, wildlife photography, trekking etc):
A.2.2 science/education (forest studies of various kinds):
B. Indirect use values (Associated with the following benefits)

B.1 Watershed protection
B.2 Soil protection, nutrient recycling and soil fertility, agricultural productivity enhancement:
B.3 Gas (eg. carbon dioxide/oxygen) exchange, contribution to carbon stabilization and carbon storage.
B.4. Habitat and protection of biodiversity and species:
B.5 Aesthetic, cultural and spiritual values:

II. Non-use values:

C. Option value:

C.1 People may value the option to use a forest in the future. Although such values are difficult to measure in economic terms, they should be recognized in value in the contributions of forests to human welfare. This concern can contribute to conservation and preservation of forest.

D. Existence and bequest value:

D.1 People may value a forest or resource complex for its existence and without any intention to directly use the resource in the future. This includes intrinsic value.
D.2 People may value a forest as a bequest to their successors or others.

Total Economic value:

\[ \text{Use values} + \text{Nonuse values} \]
4.1 Recreation valuation:

Leisure time activity voluntarily undertaken in a recreational site for the primary purpose of enjoyment it termed as recreation. Recreation is more precisely defined as an activity or planned inactivity undertaken because one wants to do it.

Some example of recreation (outdoor):

<table>
<thead>
<tr>
<th>Activity</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunting</td>
<td>Mountain climbing</td>
</tr>
<tr>
<td>Fishing</td>
<td>Snowmobiling</td>
</tr>
<tr>
<td>Hiking</td>
<td>Skiing</td>
</tr>
<tr>
<td>Horseback riding</td>
<td>Swimming</td>
</tr>
</tbody>
</table>
Bird watching. Canoeing.
Camping. Picnicking.
Bungeejumping. Elephant riding.
Rafting. Wildlife viewing.

Hence recreation is usually associated with some kinds of activity; recreation and activity are not really identical. Many of the activities given above can be, and or, undertaken by people for work as well as for fun.

- A timber contractor hikes 15 km through the forest, eats his package lunch by a brook, and calls it hard work.
- A person hikes 15 km up the Ghodepani (Kaski District) trail, eats his lunch anywhere cottage on the route of the trail, and enthusiastically calls it recreation.

Placing the value on recreational site or any recreational activity is generally termed as recreation valuation. **Travel cost method** is the widely used method to find the total economic value of a particular recreational site; though **contingent valuation method** to some extent can be applied. If different recreational sites are directly related to some environmental attributes **mixture of travel cost and hedonic pricing or mixture of contingent valuation and hedonic pricing method** may give precise result.

In order to find out the total economic value of recreation; at first we have to find the demand for recreation. Following points are quite essential for the recreation valuation.

1. **Definition of recreation:**
   For indentifying demand, a particular recreation experience must be identified as a commodity in the same way as other tangible commodities. Most recreation experiences may be recognized to be composed of five parts:
   - Planning and anticipation:
   - Travel to the site:
   - Experience to the site and participating:
   - Travel back from the site:
   - Reminiscing:
   When one discusses the demand for any particular recreational experience, one almost always discusses a composite of these five parts for the given geographical location. Finally numbers of visits should be taken as commodity not the number of visitors.

2. **Definition of price of recreation:**
   The costs of the all five components of a recreational experience must be considered as "price" and they include:
   - Cost of travel to and from the site.
   - Cost of entrance if any.
   - Cost of extra food and lodging for the time spent on the experience.
   - The opportunity cost of the time expends.

3. **The learning by doing nature of recreation:**
All tastes seem to be formed by past experience, at least to some extent. In the case of recreation, however, the fact that one has been exposed to such recreation in the past is a particularly powerful factor determining demand. Someone who has never camped outdoors in his life is likely to say that he does not like camping and, in fact, would be reluctant to spend much money and time on the activity.

4. Prices of other recreational opportunity:
In principle, the price of other recreational opportunities available to a consumer must affect his demand for a given recreational resources.

Factors affecting demand for recreation:

- Population increase.
- Higher education.
- Better health and increasing awareness of its importance.
- Availability of more leisure time.
- Greater mobility of the population.
- Higher incomes.
- Diversity of knowledge about recreation experience and site.

4.2 Valuation of environmental quality including biological diversity:

Value of environment:

- Support the production of food, timber and other rural produce.
- Provide a resource for recreation, leisure and tourism.
- Support vital ecosystem services – such as climate regulation, flood management and carbon storage.
- Provide habitats for wildlife, which is valued by people both because it adds interest to countryside activities and for its very existence.

The economic values of the natural environment consist of:

- Use values – including harvesting of food and timber, recreational values and ecosystem services;
- Non-use values – including existence, option and bequest values (Turner et al, 1994).

Linkages between the environment and the economy:
1. Activities that help to shape and manage the natural environment, such as nature and landscape conservation, agriculture and forestry. The activities of these sectors are responsible for building and maintaining the stock of natural capital.
2. Activities that benefit from the quality of the natural environment, such as tourism, fisheries, NTFP, herbal plants and the processing and marketing of “green” food and timber. These activities benefit from the services provided by natural capital.

Economic values:
Management of the land maintains and enhances the biodiversity and landscape value of the area – people enjoy visiting the area more, visitor numbers increase, while non visitors also gain satisfaction from knowing that the wildlife of the area is increasing. The management of the land also results in the production of a premium product, more highly valued by consumers and
enhancing the return to the producer. The economic value of environmental enhancements can be estimated using non-market valuation techniques (contingent valuation, travel cost, hedonic pricing) to assess values to users and non-users, and market-based measures (using data on market output to consider benefits to the producer and consumer). Since valuation of non-market benefits is often problematic, non-monetary measures (e.g. participation rates) can also be valuable. It is important to note that economic impacts and values are related, in that they both depend on the number of visitors and levels and value of marketed outputs, but that they are not the same. Economic values are measured by changes in consumer surplus (the value derived by consumers and individuals over and above the price they pay in the market) and producer surplus (the income received by producers over and above the minimum required to supply the good or service). Economic impacts are concerned with the effects that activities have on the economy (incomes and employment).

Natural Environment – Economic Values and Impacts:
Valuation of environmental quality:

Economists generally assume that individuals, not the government, are the best judges of what they want. Thus, the theory of economic valuation is based on individual preferences and choices. People express their preferences through the choices and tradeoffs that they make, given certain constraints, such as those on income or available time. The following is a brief summary of techniques used for environmental economic valuation.

1 Market price method
This method estimates economic values for ecosystem products or services that are bought and sold in commercial markets. Market-price methods rely on observing changes in prices for goods or services that are traded in a market, based on a change in environmental quality. A simple example is the change in the productivity of a commercial fishery that can be linked to a change in water quality. Market-based methods can be based on the production-based method and the expenditure-based method.

2 Productions and Expenditure Methods:
The production method estimates value by trying to gauge the contribution of the natural resource to the output derived from its (direct or indirect) use by those who rely on it for the production of environmental goods or services. For example, how much of the added value generated by tourism is attributable to the existence of a particular ecosystem, as opposed to other inputs such as produced capital, material inputs, and labour. These production-based approaches include the dose-response method and the human capital method.

The expenditure-based approaches include two distinct techniques of analysis. The first type of techniques involves actual expenditure made to alleviate an environmental problem. The second type of techniques involves potential expenditure. The expenditure-based approach includes the preventive expenditure method, mitigation cost method and the replacement cost method.

2.1 Dose-response and human capital methods
The dose response method examines changes in the money value of outputs resulting from a change in the quality of an environmental good, e.g. loss of production from a fishery affected by water pollution. The human-capital method examines forgone earnings and cost of illness to value an environmental good, e.g. the impact on health of air pollution.

2.2 Preventive cost avoided, replacement cost, and substitute cost methods
The damage cost avoided, replacement cost, and substitute cost methods are related methods that estimate values of ecosystem services based on either the costs of avoiding damages due to lost services, the cost of replacing ecosystem services, or the cost of providing substitute services. These methods do not provide strict measures of economic values, which are based on people’s willingness to pay for a product or service. Instead, they assume that the costs of avoiding damages or replacing ecosystems or their services provide useful estimates of the value of these ecosystems or services. This is based on the assumption that, if people incur costs to avoid damages caused by lost ecosystem services, or to replace the services of ecosystems, then those services must be worth at least what people paid to avoid the damage or replace the services. Thus, the methods are most appropriately applied in cases where damage avoidance or
replacement expenditures have actually been, or will actually be, made. Examples of cases where these methods might be applied include:

- valuing improved water quality by measuring the cost of controlling effluent emissions;
- valuing erosion protection services of a forest or wetland by measuring the cost of removing eroded sediment from downstream areas;
- valuing the water purification services of a wetland by measuring the cost of filtering and chemically treating water;
- loss of habitat by establishing similar habitat elsewhere;
- valuing storm protection services of coastal wetlands by measuring the cost of building retaining walls; and
- valuing fish habitat and nursery services by measuring the cost of fish breeding and stocking programs.

3 Hedonic pricing methods:

The hedonic price method uses statistical analysis of market prices to infer a price for environmental quality. The hedonic pricing method estimates economic values for ecosystem or environmental services that directly affect market prices. It is most commonly applied to variations in housing prices that reflect the value of local environmental attributes. For example, a comparison would be made between housing prices in two streets, which were similar except for the level of air pollution. It can be used to estimate economic benefits or costs associated with:

- environmental quality, including air pollution, water pollution, or noise
- Environmental amenities, such as aesthetic views or proximity to recreational site.

4 Travel cost method:

The travel cost method is used to estimate economic use values associated with ecosystems or sites that are used for recreation. The method can be used to estimate the economic benefits or costs resulting from:

- elimination of an existing recreational site;
- addition of a new recreational site; and
- Changes in environmental quality at a recreational site.

5 Contingent valuation methods:

The contingent valuation method (CVM) estimates economic values for all kinds of ecosystem and environmental services. It can be used to estimate both use and passive values, and it is the most widely used method for estimating passive values. The contingent valuation method involves directly asking people, in a survey, how much they would be willing to pay for changes in specific environmental services. In some cases, people are asked for the amount of compensation they would be willing to accept to give up specific environmental services. It is called “contingent” valuation, because people are asked to state their willingness to pay, contingent on a specific hypothetical scenario and description of the environmental service.

6 Discrete choice modeling methods:

This method estimates economic values for virtually any ecosystem or environmental service. The contingent choice method asks the respondent to state a preference between one group of
environmental services or characteristics, at a given price or cost to the individual, and another group of environmental characteristics at a different price or cost. Because it focuses on tradeoffs among scenarios with different characteristics, discrete choice is especially suited to policy decisions where a set of possible actions might result in different impacts on natural resources or environmental services. For example, improved water quality in a lake will improve the quality of several services provided by the lake, such as drinking water supply, fishing, swimming, and biodiversity. In addition, while discrete choice can be used to estimate money values, the results may also be used to simply rank options, without focusing on money values.

7 Benefit transfer method:
The benefit transfer method estimates economic values for ecosystem services by transferring available information from studies already completed in another location and/or context. For example, values for recreational fishing in a particular state may be estimated by applying measures of recreational fishing values from a study conducted in another state. The basic goal of benefit transfer is to estimate benefits for one context by adapting an estimate of benefits from some other context. Benefit transfer is often used when it is too expensive and/or there is too little time available to conduct an original valuation study, yet some measure of benefits is needed. It is important to note that benefit transfers can only be as accurate as the initial study and require conditions to be similar at both sites/contexts.

A more detailed description of these methods, together with their strengths and weaknesses can be found in:

Value of biodiversity:

**Values of biodiversity**

- **Direct values**
  - Consumptive use values
  - Productive use values
  - Social and cultural values
  - Ethical values

- **Indirect values**
  - Aesthetic values
  - Option values
  - Environment service values

**Direct values**
The direct value include food resources like grains, vegetables, fruits which are obtained from plant resources and meat, fish, egg, milk and milk products from animal resources. These also
include other values like medicine, fuel, timber, fiber, wool, wax, resin, and rubber, silk and decorative items.

The direct values are of two types (i) Consumptive use value and (ii) Productive use value.

**Consumptive use value:** These are the direct use values where the biodiversity products can be harvested and consumed directly. Example: Food, fuel and drugs. These goods are consumed locally and do no figure in national and international market.

(a) Food:

(i) Plants: The most fundamental value of biological resources particularly plants is providing food. Basically three crops i.e. wheat, maize and rice constitute more than two third of the food requirement all over the world.

(ii) Fish: Through the development of aquaculture techniques, fish and fish products have become the largest source of protein in the world.

(b) Fuel: Since ages forests have provided wood which is used as a fuel. Moreover fossil fuels like coal, petroleum, natural gas are also product of biodiversity which are directly consumed by humans.

(c) Drugs and medicines: The traditional medical practice like ayurveda utilizes plants or their extracts directly. In allopathy, the pharmaceutical industry is much more dependent on natural products. Many drugs are derived from plants like

(i) Quinine: The famous anti malaria drug is obtained from cinchona tree.

(ii) Penicillin: A famous antibiotic is derived from pencillium, a fungus.

(iii) Tetracycline: It is obtained from bacterium.

(iv) Recently found out that vinblastin and vincristine, two anti cancer drugs have been obtained from catharanthus plant which has anti cancer alkaloids.

**Productive use values:**

These are the direct use values where the product is commercially sold in national and international market. Many industries are dependent upon these values. Example- Textile, leather, silk, paper and pulp industry etc. Although there is an international ban on trade of products from endangered species like tusks of elephants, fur of many animals etc. These are traded in market and fetch a booming business.
Indirect values

Biodiversity provides indirect benefits to human beings which support the existence of biological life and other benefits which are difficult to quantify. These include social and cultural values, ethical values, aesthetic values, option values and environment service values.

Social and cultural value:

Many plants and animals are considered holy and sacred in Nepal and are worshipped like Tulsi, peepal, cow, snake etc. In Nepalese society great cultural value is given to forest and as such Laligurans and Daphe are named as the national flower and bird respectively.

Ethical:

These values are related to conservation of biodiversity where ethical issue of ‘all life forms must be preserved’ is laid down. There is an existence value which is attached to each species because biodiversity is valuable for the survival of human race. Moreover all species have a moral right to exist independent of our need for them.

Aesthetic value:

There is a great aesthetic value which is attached to biodiversity. Natural landscapes at undisturbed places are a delight to watch and also provide opportunities for recreational activities like bird watching, photography etc. It promotes eco-tourism which further generates revenue by designing of zoological, botanical gardens, national parks, wild life conservation etc.

Option values: These values include the unexplored or unknown potentials of biodiversity.

Environment service values:

The most important benefit of biodiversity is maintenance of environment services which includes

(i) Carbon dioxide fixation through photosynthesis.
(ii) Maintaining of essential nutrients by carbon (C), oxygen (O), Nitrogen (N), Sulphur (S), Phosphorus (P) cycles.
(iii) Maintaining water cycle and recharging of ground water.
(iv) Soil formation and protection from erosion.
(v) Regulating climate by recycling moisture into the atmosphere.
(vi) Detoxification and decomposition of waste.
Recap about TEV:
The framework commonly used for describing the different types of economic value ascribed to natural resources is known as Total Economic Value (TEV). The framework comprises use values (direct, indirect and option value) and non-use values.

**Direct use value** is the value derived from direct use or interaction with environmental resources and services (e.g., timber, fuelwood, recreation are direct use values of a forest). They involve commercial, subsistence, leisure, or other activities associated with a resource.

**Indirect use value** relates to the indirect support and protection provided to economic activity and property by the ecosystem’s natural functions. For example, carbon sequestration is a function of forest ecosystems whose value can be derived from the avoided costs of having to sequester by other means, or from avoiding the actual effects of warming. Similarly, the watershed protection function of a tropical forest may have indirect use value through controlling water quality and flood drainage that affect downstream agriculture, fishing, water supplies and other economic activities. While these functions have in principle long been recognized, precise field experimentation has often been lacking in order to show more precisely the relationships between ecosystem functions and the services generated.

**Option value** is a type of use value in that it relates to future use of the environment or biodiversity resources and functions. Option value arises because individuals may value the option to be able to use the natural resource sometime in the future. For example, there may be an additional premium placed on preserving a forest system and its resources and functions for future use, particularly if prospects of future value are high and if current exploitation or conversion is irreversible. The logic of the option motive is to maintain a diverse portfolio of resources as a means to reducing the risk of large fluctuations in value. A more diverse ecosystem also tends to be considerably more resilient. This has been researched under the term “insurance value” as well.

**Note**: Gregersen et al, 1995 put option value as non-use value:
**Total Economic value of biodiversity and valuation method:**

<table>
<thead>
<tr>
<th>TEV CATEGORIES</th>
<th>DIRECT USE VALUE (CONSUMPTIVE, NON CONSUMPTIVE)</th>
<th>INDIRECT USE VALUE</th>
<th>OPTION VALUE</th>
<th>NON USE VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunting; Fishing Timber harvesting; Harvesting of NTFP; Harvesting of biomass; Recreation.</td>
<td></td>
<td></td>
<td>Genetic resource; Old - growth forest (Irreversibility)</td>
<td>Existence value; Bequest value (For future generation)</td>
</tr>
</tbody>
</table>

**COMMONLY USED VALUATION METHOD**

A: Change in productivity  
B: Cost-based approach  
C: Hedonic price  
D: Travel cost  
E: Stated preference method

**EXAMPLE OF BIODIVERSITY**

- Hunting; Fishing  
- Timber harvesting; Harvesting of NTFP; Harvesting of biomass; Recreation.

**WATERSHED PROTECTION** (erosion control, local flood reduction, regulation of stream flows, storm protection)

**ECOLOGICAL PROCESS** (Fixing and cycling of nutrients, soil formation, circulation and cleaning of air and water, climate regulation, carbon fixing, global life support)

**EXAMPLE OF BIODIVERSITY COMMONLY USED VALUATION METHOD**

- A, B, C, D, E  
- A, B, E  
- A, B, E  
- E
1. Changes in productivity:
One widely used technique, thanks to its broad applicability and its flexibility in using a variety of data sources, is known as the change in productivity technique. It consists of tracing through chains of causality so that the impact of changes in the condition of an ecosystem can be related to various measures of human well-being. Such impacts are often reflected in goods or services that contribute directly to human well-being (such as production of crops or of clean water), and as such are often relatively easily valued. The valuation step itself depends on the type of impact but is often straightforward.

The impact of hydrological changes on use of water for human consumption, for example, begins by tracing through chains of causality to estimate the changes in the quantity and quality of water available to consumers. This is itself often difficult. For instance, the relationship between tree cover and water productivity in a watershed is complex and often not well understood. Further scientific research into this relationship and the chains of causality will in such cases be a key precondition for valuation. In the case of marketed goods, the actual valuation is relatively straightforward. For instance, the net value in reductions in irrigated crop production resulting from reduced water availability is easy to estimate, for example, as crops are often sold. (Even so, it is a very common error to use the reduction in the gross value of crop production rather than the net value. Using gross value omits the costs of production and so overestimates the impact.).

Where the impact is on a good or service that is not marketed or where observed prices are unreliable indicators of value, the valuation can become more complex. In the example above, it has to be noted that the prices charged to consumers for water consumption are typically not reliable measures of the value of the water to consumers, as they are often set administratively, with no regard for supply and demand (indeed, in most cases water fees do not even cover the cost of delivering the water to consumers, let alone the value of the water itself). The value of an additional unit of water can then be estimated in various ways, such as the cost of alternative sources of supply (cost-based measures are described later) or asking consumers directly how much they would be willing to pay for it (contingent valuation, described later). Note that it is very important to use the value of an additional unit of water, since some amount of water is, of course, vital for survival. Thus an additional unit of water will be very valuable when water is scarce, but much less so when water is plentiful. In this case, as in many others, averages can be misleading.

When the impact is on water quality rather than quantity, the impact on well-being might be reflected in increased morbidity or even mortality. Again, the process begins by tracing through chains of causality, for example by using dose-response functions that tie concentrations of pollutants to human health. Valuing the impact on health itself can then be done in a number of ways.

In some cases, the impact is on relatively intangible aspects of well-being, such as aesthetic benefits or existence value. Starting in the 1960s, particular efforts have been made to develop techniques to value such impacts, including hedonic price, travel cost, and contingent valuation methods, and considerable progress has been made since then.

2. Cost of illness and human capital
The economic costs of an increase in morbidity due to increased pollution levels can be estimated using information on various costs associated with the increase: any loss of earnings resulting from illness; medical costs such as for doctors, hospital visits or stays, and medication; and other related out-of-pocket expenses. The estimates obtained in this manner are interpreted
as lower-bound estimates of the presumed costs or benefits of actions that result in changes in the level of morbidity, since this method disregards the affected individuals’ preference for health versus illness and restrictions on non-work activities. Also, the method assumes that individuals treat health as exogenous and does not recognize that individuals may undertake defensive actions (such as using special air or water filtration systems to reduce exposure to pollution) and incur costs to reduce health risks.

When this approach is extended to estimate the costs associated with pollution-related mortality (death), it is referred to as the human-capital approach. It is similar to the change-in-productivity approach in that it is based on a damage function relating pollution to productivity, except that in this case the loss in productivity is that of human beings, measured in terms of expected lifetime earnings. Because it reduces the value of life to the present value of an individual’s future income stream, the human-capital approach is extremely controversial when applied to mortality. Many economists prefer, therefore, not to use this approach and to simply measure the changes in the number of deaths or in the probability of death (without monetary values), or measures such as disability-adjusted life years.

3. Cost-based approaches:
The costs of replacing or restoring the services provided by the environmental resource can sometimes be relevant variables in decision-making. For example, if ecosystem change reduces water filtration services, the cost of treating water to make it meet the required quality standards could be used. The major underlying assumptions of these approaches are that the nature and extent of physical damage expected is predictable (there is an accurate damage function available) and that the costs to replace or restore damaged assets can be estimated with a reasonable degree of accuracy. It is further assumed that the replacement or restoration costs do not to exceed the economic value of the service, bearing in mind that potential externalities generated by the replacement options should also be taken into consideration. These assumptions may not be valid in all cases. It simply may cost more to replace or restore a service than it was worth in the first place—for example, because there are few users or because their use of the service was in low-value activities.

Even while there is not necessarily any relationship between the replacement or restoration cost and the value of the service, cost-based approaches can provide useful guidance in a number of cases, in particular when the specific decision-making problem calls for a comparison of the costs resulting from all different replacement or restoration options. For instance, in an often-quoted case, the New York City water authority avoided spending $6-8 billion on water purification plants by investing $1.5 billion for protection and restoration of the upstate watershed of the Catskills mountains. Here, the decision-making problem was simply to minimize the cost of meeting an objective, by comparing the costs resulting from replacement and from restoration options. The priority given to the objective itself (a reliable supply of drinking water meeting certain quality standards) was unquestionable and, hence, not part of the decision-making problem.

4. Hedonic analysis:
The prices paid for goods or services that have environmental attributes differ depending on those attributes. Thus, a house in a clean environment will sell for more than an otherwise
identical house in a polluted neighbourhood. Hedonic price analysis compares the prices of similar goods to extract the implicit value (also dubbed “shadow price”) that buyers place on the environmental attributes. This method assumes that markets are transparent and work reasonably well, and it would not be applicable where markets are distorted by policy or market failures. Moreover, this method requires a very large number of observations, so its applicability is limited.

5. Travel cost:
The travel-cost method is an example of a technique that attempts to deduce value from observed behaviour in a surrogate market. It uses information on visitors’ total expenditure to visit a site to derive their demand curve for the site’s services. From this demand curve, the total benefit visitors obtain can be calculated. (It is important to note that the value of the site is not given by the total travel cost; this information is only used to derive the demand curve.) This method was designed for and has been used extensively to value the benefits of site-seeing or of recreation at particular sites, but it has limited utility in other settings.

6. Contingent valuation
Contingent valuation is an example of a stated preference technique. It is carried out by asking consumers directly about their willingness-to-pay to obtain an environmental service. A detailed description of the service involved is provided, along with details about how it will be provided. The actual valuation can be obtained in a number of ways, such as asking respondents to name a figure (classical CV), asking them whether they would pay a specific amount (dichotomous or polychotomous choice) or having them choose from a number of options (choice modeling).

Contingent valuation can, in principle, be used to value any environmental benefit simply by phrasing the question appropriately. Moreover, since it is not limited to deducing preferences from available data, it can be targeted quite accurately to ask about the specific changes in benefits that the change in ecosystem condition would cause. Because of the need to describe in detail the service being valued, interviews in contingent valuation surveys are often quite time-consuming. It is also very important to identify the relevant population, to ensure representativeness of the sample of respondents, and to have the questionnaire extensively pre-tested to avoid various sources of bias.

A potentially important limitation in terms of applying these methods to ecosystem services is that respondents cannot typically make informed choices if they have a limited understanding of the issue in question. Choosing the right approach for, and the adequate intensity of efforts in, improving the understanding of biological complexity of the sample group is a challenge for stated preference methods.

Contingent valuation methods have been the subject of severe criticism by some analysts, in particular because a number of biases can occur that would lead contingent valuation studies to not reflect true preferences:

- One major issue is that of so-called zero-bids, that is, respondents that state to have no willingness-to-pay at all. In some cases, such an occurrence can be explained by economic theory—the service in question is not valued by the respondent or his/her budget restrictions are too tight. However, zero-bids can also reflect protest—respondents who are not agreeing
that they should pay for the service in question and who consider someone else responsible, for instance the government or the polluter. A zero-response may also be given when no trade-offs for the service are accepted at all (so-called lexicographic preferences). Finally, protest bids can also occur when the survey itself is rejected as a methodology, or payment vessels are not accepted.

- Exaggerated willingness-to-pay statements are possible as well, for different reasons: (i) The phenomenon of “yea-saying” has been shown to occur sometimes—respondents will agree to a proposal or bid to please the interviewer or avoid further questions. (ii) The existence of a “warm glow” can also have an influence; respondents tend to feel good about giving, about being “good” or “nice”, and will initially offer higher willingness-to-pay than after thorough consideration. (iii) Strategic behaviour can also occur: participants will state unrealistic willingness-to-pay numbers in an attempt to influence the outcome of the study. (iv) Willingness-to-pay statements tend to also be elevated due to a lack of awareness of possible substitutes.

- Another source of bias can be through the interviewer giving information that is not fully neutral, or formulating questions to favour certain answers.

Contingent valuation can provide useful and reliable information when used carefully, and it provided guidance thereon that can help to reduce or avoid many of the biases described above. The requirements may be following:

- The design of contingent valuation studies should be conservative, always rather allowing for an underestimate than an overestimate of willingness-to-pay.
- Because the concept of willingness-to-accept is a source of potential bias, willingness-to-pay should be preferred over willingness-to-accept.
- The valuation questions are to be asked as a vote on a referendum, not completely open.
- Sufficient information must be provided, however care is necessary in the use of pictures, including the pre-testing their effect on participants, and possibly making another choice.
- Participants should be made aware of substitutes for the good being evaluated.
- Sufficient time should pass after a negative impact on the ecosystem before a contingent valuation study is conducted in order to avoid answers out of a momentary disposition. Answers averaged over several points in time can avoid catching temporary changes in preferences.
- Respondents should be able to refuse an answer, with an attempt to be made of finding out the reasoning behind both refusals to answer and yes/no answers.
- A high quality survey would also include questions on socioeconomic data and respondents’ general attitudes and perceptions of the issue at stake, with the influence of these variables on the willingness-to-pay being analyzed.
- Lastly, with all the above guidelines met, the questionnaire must still be easy enough to understand and not take an excessive amount of time to complete.

Dichotomous or polychotomous choice is a variant of Contingent Valuation where instead of open questions the respondents are asked whether they would pay a certain amount. Dichotomous choice allows only for “yes” and “no” answers, polychotomous choice provides more options such as “probably pay”, “certainly pay” or “not sure”. Questions can be single-bounded, where only one question is asked, or multiple-bounded, where follow-up questions with higher or lower amounts, depending on the initial reply, are asked. There are usually
different versions of a questionnaire with different amounts being initially offered for choice. This technique makes answering easier for respondents, thereby reducing the chance of unrealistic statements. It does however bear the risk of starting point bias, that is, researchers influencing outcomes by choosing certain starting points.

7. Choice Modelling

Choice modelling (also referred to as contingent choice, choice experiments, conjoint analysis, or attribute-based stated choice method) is a newer approach to obtaining stated preferences. It consists of asking respondents to choose their preferred option from a set of alternatives where the alternatives are defined by attributes (including the price or payment). The alternatives are designed so that the respondent’s choice reveals the marginal rate of substitution between the attributes and the item that is trade off (e.g., money). These approaches are useful in cases in which the investigator is interested in the valuation of the attributes of the situation or when the decision lends itself to respondents choosing from a set of alternatives described by attributes.

Choice modelling has several advantages: the control of the stimuli is in the experimenter’s hand, as opposed to the low level of control generated by real market data; the control of the design yields greater statistical efficiency; the attribute range can be wider than found in market data; and the introduction or removal of products, services and attributes is easily accomplished (Louviere et al. 2000; Holmes and Adamowicz 2003; Bateman et al. 2004). The method also minimizes some of the technical problems associated with contingent valuation, such as strategic behaviour of respondents. The disadvantages associated with the technique are that the responses are hypothetical and therefore suffer from problems of hypothetical bias (similar to contingent valuation) and that the choices can be quite complex when there are many attributes and alternatives. The econometric analysis of the data generated by choice modelling is also fairly complex.

8. Benefits transfer:

A final category of approach is known as benefits transfer. This is not a methodology per se but rather refers to the use of estimates obtained (by whatever method) in one context to estimate values in a different context. For example, an estimate of the benefit obtained by tourists viewing wildlife in one park might be used to estimate the benefit obtained from viewing wildlife in a different park. Alternatively, the relationship used to estimate the benefits in one case might be applied in another, by using adjusted data from this case in conjunction with some data from the site of interest (“benefit function transfer”). For example, a relationship that estimates tourist benefits in one park, based in part on their attributes such as income or national origin, could be used in another park, but with data on income and national origin of that park’s visitors.

Benefits transfer has been the subject of considerable controversy in the economics literature, as it has often been used inappropriately. According to the Millennium Ecosystem Assessment, a consensus seems to be emerging that benefit transfer can provide valid and reliable estimates under certain conditions. These conditions include the requirement that the commodity or service being valued be very similar at the site where the estimates were made and the site where they are applied and that the populations affected have similar characteristics. Of course, the original estimates being transferred must themselves be reliable in order for any attempt at transfer to be meaningful.
As the conditions at the two sites are unlikely to be perfectly identical, some transfer error is to be expected. This feature, however, does not speak as such against the application of benefits transfer in real-world decision-making. This is because estimates based on benefits transfer can be generated with considerably less time and resources than primary studies. In a world of scarce resources and typically very costly primary studies, decision makers may be willing to trade quick and cheap numbers against a certain loss in accuracy, provided that minimum quality standards are met. They may even be more ready to do so when the relevant alternative, under given resource constraints, is simply to have no estimate at all. Moreover, benefits transfer may be attractive when decision makers request, as is frequently the case, quick (but not necessarily final) answers from administrators—it may hence play a role within rapid assessment methodologies.

9. Summary assessment of valuation methods

Each of the approaches reviewed above has seen extensive use in recent years, and considerable literature exists on their application. These techniques can and have been applied to a very wide range of issues (Rietbergen-McCracken and Abaza 2001), including the benefits of ecosystems such as forests (Bishop 1999; Kumari 1995; Pearce et al. 2002; Hanley et al. 2002, Merlo and Croitoru 2005), wetlands (Barbier et al. 1997; Heimlich et al. 1998; de Groot et al. 2006), watersheds (Aylward 2004; Kaiser and Roumasset 2002). Other studies have focused on the value of particular ecosystems services such as water (Young and Haveman 1985), non-timber forest benefits (Lampietti and Dixon 1995; Bishop 1998), recreation (Bockstael et al. 1991; Mantua at al. 2001; Herriges and Kling 1999; Humavindu 2002), landscape (Garrod and Willis 1992; Powe et al. 1995), biodiversity for medicinal or industrial uses (Simpson et al. 1994; Barbier and Aylward 1996), natural crop pollination and cultural benefits (Pagiola 1996; Navrud and Ready 2002). Many valuation studies are catalogued in the Environmental Valuation Reference Inventory Web site maintained by Environment Canada (EVRI) or the ENVALUE environmental valuation database developed by the New South Wales Environmental Protection Agency of Australia.

It appears that, when applied carefully and according to best practice, valuation tools can generally provide useful and reliable information on the changes in the value of non-marketed ecosystem services that result (or would result) from management decisions or from other human activities. Data requirements may be quite demanding for a number of tools, as are the preconditions in terms of technical expertise. Moreover, conducting primary valuation studies is typically time-consuming and costly.

According to the Millennium Ecosystem Assessment, measures based on observed behaviour are generally preferred to measures based on hypothetical behaviour, and more direct measures are preferred to indirect measures. However, it is also pointed out that the choice of valuation technique in any given instance will be dictated by the characteristics of the case, including its scope, and by data availability.

Several techniques have been specifically developed to cater to the characteristics of particular problems. The travel cost method, for example, was specifically developed to measure the utility derived by visitors to sites such as protected areas, and could also be applied to similar areas of
interest, but is of limited applicability outside that particular case. The change in productivity approach, on the other hand, is applicable to a wide range of issues. Contingent valuation is potentially applicable to any issue, simply by phrasing the questions appropriately and as such has become very widely used—probably excessively so, as it is easy to misapply and, being based on hypothetical behaviour, is inherently less reliable than measures based on observed behaviour. For instance, if the focus is on the quantification of indirect use values, the application of other valuation tools would often seem to be preferable. For some types of value, however, stated preference methods may be the only alternative. Thus, existence value can only be measured by stated preference techniques. Guidance on the appropriate use of the technique exists and should be followed closely. Benefits transfer has often been used inappropriately but can provide valid and reliable estimates under certain conditions. Given the cost of undertaking primary valuation studies, benefits transfer when used cautiously is likely to be an increasingly appealing way for extending the use of valuation, including in developing countries.

4.3. Forest stumpage:
Stumpage is defined as the trees, standing in the forest, uncut. The stumpage price is the price paid for the right to cut the trees from their stumps and remove them from the forest. Stumpage is valued by estimating its market values.

Stumpage valuation may be abstracted into two parts:

<table>
<thead>
<tr>
<th>The first part is to estimate the volume of timber in the proposed sale. This can include an estimate of volume by species and size or quality class.</th>
<th>The second part is to estimate the market price per unit of volume.</th>
</tr>
</thead>
</table>

The total sale value is the product of the volumes and their estimated market prices.

Both the buyer and the seller want market value estimates. The buyer does not want to pay more for the timber than he could purchase it for elsewhere, and the seller wants to be sure he is paid at least as much for the timber as he can get elsewhere. The buyer may also want to estimate his cost of converting the timber to a merchantable product to be sure that his costs, including the stumpage price, do not exceed the selling price of the merchantable timber. The market price is then determined by the buyer's and seller's interaction.
Example of stumpage valuation:
Let us take a simple example of a land area where tree is grown for timber production only, assume there is no any other products. Assume competitive conditions, one region, one species, and a given quality of timber that mills sell for Rs 1000 per cft. Suppose, this is a price that each mill must accept as a price taker and it costs a mill Rs 400 per cft. Including profit, to process delivered logs into timber and distribute it to buyers. Then such a mill would be willing to pay up to Rs 1000- 400 = Rs 600 per cft for logs delivered to the mill. Suppose a logger can receive Ra 600 per cft for deliver logs, and it cost Rs. 200 per cft for logging and hauling of a given type and location of stumpage (This include building logging roads, administration, felling, skidding, loading, and profit). The logger would be willing to pay up to Rs. 600-200 = Rs. 400 per cft for such stumpage. In summary this is shown below.

<table>
<thead>
<tr>
<th>Sn.</th>
<th>description</th>
<th>amount Rs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Timber sale price</td>
<td>1000.00</td>
</tr>
<tr>
<td>2.</td>
<td>Costs of logging etc.</td>
<td>-200.00</td>
</tr>
<tr>
<td>3.</td>
<td>Cost of milling etc.</td>
<td>-400.00</td>
</tr>
<tr>
<td></td>
<td>Residual for stumpage</td>
<td>400.00</td>
</tr>
</tbody>
</table>

Hence valuation for stumpage is Rs. 400 per cft.

4.3 Concept of shadow pricing and Shadow wages rate:

Initial understanding of shadow price and shadow wage rate by maximization problem:
Supposing,

- A firm is engaged in producing two products A and B.
• Each unit of A requires 2 kg of raw materials and 4 hours of labour.
• Each unit of B requires 3 kg of raw materials and 3 hours of labour.
• Every week the firm has an availability of 60 kg of raw materials and 96 of labour hours.
• One unit of product A sold yields Rs 40 and one unit of product B sold give Rs 35 as profit.

The problem can be formulated as LPP as below.

Maximize: $Z = 40x_1 + 35x_2$  Profit
Subject to:
\[
\begin{align*}
2x_1 + 3x_2 & \leq 60 \quad \text{- Raw materials constraint} \\
4x_1 + 3x_2 & \leq 96 \quad \text{- Labour hour's constraint}
\end{align*}
\]

After solving the problem the final tableau will be as:

<table>
<thead>
<tr>
<th>Basis</th>
<th>$x_1$</th>
<th>$x_2$</th>
<th>$s_1$</th>
<th>$s_2$</th>
<th>$b_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_2$</td>
<td>35</td>
<td>0</td>
<td>1</td>
<td>$\frac{2}{3}$</td>
<td>$-\frac{1}{3}$</td>
</tr>
<tr>
<td>$x_1$</td>
<td>40</td>
<td>1</td>
<td>0</td>
<td>$-\frac{1}{2}$</td>
<td>$\frac{1}{2}$</td>
</tr>
<tr>
<td>$c_i$</td>
<td>40</td>
<td>35</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>solution</td>
<td>18</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$z_j$</td>
<td>40</td>
<td>35</td>
<td>$\frac{10}{3}$</td>
<td>$\frac{25}{3}$</td>
<td></td>
</tr>
<tr>
<td>$\Delta_j (c_j-z_j)$</td>
<td>0</td>
<td>0</td>
<td>$-\frac{10}{3}$</td>
<td>$-\frac{25}{3}$</td>
<td></td>
</tr>
</tbody>
</table>

Now, suppose the firm is approached by an individual who would like to rent the facilities of the firm for one week. The firm has its assets in the form of 60 kg of raw materials and 96 labour hours per week. If we let $y_1$ represent the rental rate per kg of raw material and $y_2$ the rental rate per labour hour, the firm would receive a total rental equal to Rs. $60y_1 + 96y_2$. We shall compute the minimum value of the rental so that the firm well knows as to what minimum offer shall be economically acceptable to it. The constraint can be set up by keeping in mind that the alternative of renting must be at least as favourable as the other ones. The rental rates of the resources should be at least as attractive as producing products A and B. We know that production of one unit of A requires 2 kg of raw materials and 4 labour hours. Thus, the total rental for these amounts of resources should be greater than, or equal to, the profit obtainable from one unit of the product i.e. Rs. 40, thus we should have;
\[
2y_1 + 4y_2 \geq 40
\]
Similarly, with respect to labour hours, we should have;
\[
3y_1 + 3y_2 \geq 35
\]
The rental of $y_1$ and $y_2$ can be found out from the above tableau as $\frac{10}{3}$ and $\frac{25}{3}$ corresponding to the slack variable $s_1$ and $s_2$ considering absolute value. These values are the shadow prices or imputed prices of the raw materials and labour hours respectively. Hence the prices assigned to the services of the two resources, raw materials and labour hours, are imputed from the profit obtained from utilizing their services, and bear no relationship with the original cost of the two. Hence,
\[
40 \times 18 + 35 \times 8 = 1000 \\
60 \times \frac{10}{3} + 96 \times \frac{25}{3} = 1000
\]
Both are equals. Therefore, rental price of $y_1$, which is Rs 10/3 is the shadow prices of the raw materials per kg and rental prices of the $y_2$ which is Rs 25/3 is the shadow wages of labour per hour.

**Shadow price:**
An imputed valuation of a commodity or services which has no market price is called shadow price. Shadow prices are used in environmental attributes valuation and cost-benefit analysis of any project. Shadow price represents the planned opportunity cost of producing or consuming a commodity which is generally not traded in the economy. Even in a market economy certain outputs such as health, educational and environmental quality do not attract a market price. A set of shadow prices representing consumers' marginal rate of substitution or producer marginal rates of transformation between such commodities may be calculated reflecting the marginal costs of production or the marginal values of their uses as inputs. To the extent that market prices do not reflect opportunity costs-benefit analysis may substitute shadow prices.

**Wages:**
Wages are payments for the services of labour, whether mental or physical. Though in ordinary language an office executive, a minister or teacher is said to receive a salary; a lawyer or doctor a fee; and a skilled or unskilled worker a wage, yet in economics no such distinction are made for different services and all of them are said to receive wages. In other words, wages includes fees, commissions and salaries.

**Shadow wage rates:**
The shadow price of labour is called shadow wage rate.

**Shadow Pricing:**
Where price does not reflect the actual value of a good or commodity, or no market value for a good or commodity exists, shadow pricing can be used. Shadow pricing is a proxy value of a good, often defined by what an individual must give up to gain an extra unit of the good. The value of a good or impact resulting from a project when measured using shadow pricing may, however, differ from the value of that or similar goods or impacts when measured using market prices. This occurs due to market failure in real markets which impacts on the shadow value of certain goods and impacts. A number of examples of this are given in the table below which has been adapted from Stiglitz (2000, 283).

<table>
<thead>
<tr>
<th>Market</th>
<th>Difference between Market and Shadow Price</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td>Shadow wage is less than market wage when there is unemployment.</td>
<td>No loss in output elsewhere when individual gains employment, so marginal social cost of hiring this individual is lower than market wage.</td>
</tr>
<tr>
<td>Capital</td>
<td>Shadow interest rate is greater than market interest rate when</td>
<td>Expected return is greater than interest rate as firms wish to</td>
</tr>
</tbody>
</table>

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<td>Capital</td>
<td>Shadow interest rate is greater than market interest rate when</td>
<td>Expected return is greater than interest rate as firms wish to</td>
</tr>
</tbody>
</table>
There is rationing in capital markets. Borrow more at given interest rate than they can. Opportunity cost of funds is greater than interest rate.

| Steel | Shadow price is greater than market price. | Steel producer does not account for marginal social cost of pollution in production costs. |

In some cases shadow pricing can be used to obtain a valuation of the impacts of a project, whether benefits or costs, using stated and revealed preferences. In so many cases of non market valuation of environmental attributes shadow price is used.

‘Stated’ or ‘Expressed’ Preferences

Collecting data on stated or expressed preferences involves asking individuals directly to express how they feel about the certain environmental attributes. This method is usually applied where attributes are either doing not have a market price, or a market price is deemed inappropriate. Stated or expressed preferences are a contingent valuation method of data collection which involve the use of either willingness to pay or willingness to accept measures of a good or commodity.

Willingness to Pay:

If collecting data on benefits this measure will usually involve asking an individual, using a survey or questionnaire, about their willingness to pay for some sort of benefit, for example improved journey times, or the preservation of a local park. The willingness to pay method has been used worldwide to evaluate the ‘use value’ of an amenity to individuals. This is actually the shadow price of the attributes.

Willingness to Accept:

Equally a willingness to accept measure can be used. This involves asking individuals how much they would be willing to accept in compensation to consume more undesirable goods or commodities. For example, what monetary compensation would a fisherman accept to continue living along a coastline impacted by an oil spill?

Total Economic Value

The total economic value (TEV) of a resource or amenity reflects not only the value we associate with our current use of the amenity (the ‘use value’) but also the potential future value we consider the amenity to have, and the value we associate simply with the existence of the resource or amenity.

This can be expressed as follows:
TEV = Use Value + Option Value + Existence Value

The Bias Problem

Collecting data from individuals using a questionnaire method can suffer from a key problem relating to bias. When attempting to apply a valuation to some cost or benefit of a project or valuing environmental attributes two potential biasing problems may be encountered:

(1) Bias in the sample: In most cases the researcher involved in the BCA or valuing an environmental attributes will have limited resources (time and financial). This means that a sample will have to be chosen to collect the stated preference data on the costs/benefits associated with a project or environmental valuation. However, in collecting data using only a sample of the wider population potential bias can be found. This will be a particular problem if only a small sample of individuals is surveyed as part of the data collection. For example, if a survey samples only 100 individuals, and within this sample 12 are members of a local environmental action group, the responses of these individuals could bias the overall results. This problem can be addressed, at least to a certain extent, by collecting data from a large sample, and through use of sampling methods which ensure a representative cross-section of individuals.

(2) Bias in responses: Asking individuals directly about their willingness to pay or willingness to accept may illicit a stronger view from the individuals than they actually have. For example, when asking individuals how much they would be willing to pay to preserve an area of local parkland they may apply a significantly larger monetary valuation than they would really be willing to pay, knowing that they would not actually be asked to pay this amount should the parkland be preserved. Moreover, individuals may state a willingness to pay to preserve an amenity such as a local park, even though they actually never visit the park and may consider it a nuisance at night when children hang around on the park.

Determination of the shadow wage rate:
The determination of the shadow wage rate is a difficult problem because labourers differ in efficiency. Therefore shadow price of labour cannot be the same for both the skilled and unskilled labour and for different types of skilled labour. In under developed countries there is surplus labour in the rural areas having almost zero marginal products. But its shadow price cannot be assumed to be zero; it should be positive and provide a minimum subsistence level when such labor is employed on construction works. But even of the marginal product of the labour is less than the wage, it does not necessarily follow that one should use a shadow price for labour lower than the wage. This is because wage earners tend to consume most or all the wages which they are paid. Thus the payment of wages constitutes real cost to the economy, even if there is no alternative employment for labour. Therefore, some economists are of the view that the accounting price for labour can be fixed anywhere above the zero marginal product of labour, and with the increase in the marginal product of the labour its accounting price can also be raised. But according to the UN experts, assuming no surplus of skilled labour but ample supplies of agricultural and unskilled labour the accounting prices of different kinds of skilled labour can be based on the cost of moving workers from villages to industrial areas, providing them with houses and other facilities, and training them.
4.5 Non-market valuation:

Without the observable price and quantity data that are available when goods or services are traded in the market, economists have devised innovative techniques for measuring changes in value for natural resources and the environment. Three of the techniques, travel cost, random utility and hedonics use information to indirectly determine what a market might reveal in value if it did exist. The contingent value technique attempts to measure the change in value directly.

<table>
<thead>
<tr>
<th>Indirect Measurement Techniques</th>
<th>Direct Techniques:</th>
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</thead>
<tbody>
<tr>
<td>• Travel Cost Model</td>
<td>• Contingent Valuation Method</td>
</tr>
<tr>
<td>• Random Utility Models</td>
<td>(Stated preference)</td>
</tr>
<tr>
<td>• Hedonic Techniques</td>
<td></td>
</tr>
<tr>
<td><em>(Revealed preference)</em></td>
<td></td>
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</table>

Some goods and services like recreational fishing and wildlife viewing are not traded in a well functioning, traditional market. That is, they are not supplied by private firms and consumers do not pay market prices. Nonetheless, individuals benefit from their use and, therefore, the loss of such environmentally related goods signifies welfare losses to these individuals. Conceptually, the same measure of benefit applies to market and non-market goods, that is, the maximum amount an individual would pay to avoid losing, or gaining, access to the good. Since these are non-market benefits, typically, there is no producer, or the consumer is both the producer and consumer. Thus, measures of non-market benefits are concerned with estimates of consumer demand and consumer surplus. There are a variety of methods that have been developed to measure this value concept in the absence of markets.

Non-Market Valuation Techniques:

In the absence of ownership and efficient pricing, we need special techniques to place consumer preferences for natural resources and environmental goods and services on common ground with the demands for more conventional commodities. Three types of procedures have been employed to measure these demands.

- Travel cost and random utility models, which are based on expenditures and travel behaviour for recreational opportunities.
- Hedonic methods of decomposing prices of market goods to extract embedded values for related environmental attributes.
- Experimental methods for eliciting preferences, either by using hypothetical settings, called contingent valuation, or by constructing a market where none existed.

Travel cost models, random utility models, and hedonic methods are indirect measures based on observable behavior. Experimental methods, or contingent valuation, are based on direct surveys of individuals.
INDIRECT MEASUREMENT TECHNIQUES:

Indirect techniques rely on observable behaviour to deduce how much something is worth to an individual even though it is not traded in markets. These methods produce value estimates that are conceptually identical to market values, but they must be measured more creatively since market data are not available. Indirect techniques include travel cost models, random utility models, and the hedonic pricing method.

TRAVEL COST MODEL:
Overview:
The travel cost method is, in general, employed to estimate recreational values. This technique assumes that visitors to a particular site incur economic costs, in the form of outlays of time and travel expenses, to visit the site. In effect, these economic expenditures reflect the “price” (albeit implicit) of the goods and services provided by the site, and are an indirectly observable indication of the minimum amount that a visitor is willing to pay to use the site (with all its associated attributes).

By observing the characteristics of individuals visiting the site—for example, the specific attributes of their trip to and from the site as well as the total number of visits—economists are able to estimate the “derived demand” for the site. That is, for any given or implicit price, the derived demand relationship will determine the number of visits consumers will “purchase” at that site.

The travel cost model technique has a number of applications - it can be used, for example, to measure the effects on a consumer’s willingness-to-pay because of changes in access costs to a recreational area, or the elimination of a site, or changes in environmental quality.

Issues that Require Attention in Travel Cost Modeling:

- Costs, because time costs are often critical in recreational consumption.
- Characterizing the quality dimensions of the site and taking proper account of substitute sites and their characteristics.
- Estimating both the individual’s decision as to whether to use the site and his or her decision as to how much to use it.

Advantages of This Technique:

The travel cost technique is relatively uncontroversial because it mimics empirical techniques used elsewhere in economics. Economists generally tend to prefer techniques of this sort because they are based on actual behaviour rather than verbal responses to hypothetical scenarios. In the travel cost model, individuals are actually observed spending money and time, and their economic values are deduced from their behaviour. In appropriate circumstances, this model can often be applied without enormous expense.

Disadvantages of This Technique:

The greatest disadvantage of travel cost and other indirect techniques is that they cannot be employed unless there is some easily observable behaviour that can be used to reveal values. Thus, in the case of measurement of nonuse values these methods are inappropriate. In the case
of nonuse values, there is no observable interaction between the individual and the resource in question. Travel cost models is also technically and statistically complicated. Understanding the conceptual measure requires understanding the connection between consumer surplus (measures of changes behind demand curves) and the “maximum willingness to pay” concept. In addition, data must be employed to statistically estimate increasingly sophisticated econometric models that take into account such factors as sample selection problems and non-linear consumer surplus estimates. Finally, the resulting estimates sometimes have been found to be rather sensitive to arbitrary choices of the functional form of the estimating equation and the treatment of time. Though much technical work has been dedicated to improving these methods, they will continue to be subject to the problems that plague all empirical economic estimation.

Data Needs:

While the early travel cost models used information on the proportions of visitors from increasingly distant zones of origin from which their travel occurred (called “zonal models”), current methodology requires data on individual travelers. Typically this information is collected through surveys. On-site surveys can provide heavy sampling of users, but these need to be augmented with surveys of the general population in order to learn what proportion of the population uses the resource. A survey of the general population also provides data on the characteristics of the resource users as well as information that helps the economist estimate the participation decision. Unfortunately, a travel cost study is best at assessing the current situation. To analyze the gains or losses from changes in the recreational resource, economists need to conduct travel cost studies under varying circumstances or they need a way of extrapolating the effects of change. Ideally, an important recreational resource could be subject to periodic travel cost studies, so that the effect of differing conditions of the resource could better be estimated. This is especially true if one is measuring the damages from a disaster such as the effects of an oil spill on recreational boating. Economists would find invaluable a travel cost study that had been completed before the disaster.

Estimating the Value of Recreational Bird-watching
Travel Cost Model:

Suppose a development project calls for filling a wetlands area, an area that is a major bird-watching site for the region. In this case the valuation question might be: What would be a money measure of the lost value of observing birds in this area due to the development? The answer could be used as input to a benefit-cost analysis of the proposed development.

The first step in such an analysis is to survey participants on bird-watching trips about trip expenses. The second step would examine the relationship between the number of participants and trip expenses such as in the table.

<table>
<thead>
<tr>
<th>Trip Expense Range (Rs)</th>
<th>Number of trips</th>
</tr>
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<tbody>
<tr>
<td>Less than 10</td>
<td>50</td>
</tr>
<tr>
<td>10 to 19</td>
<td>25</td>
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<tr>
<td>20 to 29</td>
<td>13</td>
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</table>
In the absence of such ideal studies, researchers would find any information on the level of use of the resource beneficial (e.g., historical information on number of users, their location of residence, and frequency of use). Moreover, any information that would help shape the sampling method would be valuable (e.g., when the resource is most heavily used and by whom).

As with all environmental valuation, the researcher’s most difficult job is connecting the environmental event with the effect on the user. Any insights here are invaluable. In the development case, the analysis would need to be accomplished as a hypothetical case. To use results from a travel cost model, researchers need to know how recreationists would be affected by the development activity and how that effect would translate into changes in behaviour.

From this and other data collected about the individual participants, we can estimate a travel cost demand curve with the travel cost as the price and the number of trips as the quantity shown in Figure.

This demand curve will also be a function of other information collected from the individuals that help to explain their bird-watching behaviour (e.g., income, ethnicity, education, etc.). We must also make adjustments econometrically for the non-participants, the people who might go bird-watching in the area under different circumstances (e.g., if they had lower travel costs) The travel cost demand curve applies to a representative individual from a particular geographic
region or socio-economic class. It is not the aggregate demand curve. To get an aggregate value measure, individual consumer surplus must be augmented by a population expansion factor which this individual represents.

This curve represents the recreational demand for bird-watching prior to the development. If bird-watching is completely eliminated at this site, then the total consumer surplus is lost. However, the more likely consequence is that the quality of the bird-watching trip will be lowered. We will need to predict how the demand curve will shift, and then measure the consumer surplus with and without the shift.

**Summary of the Travel Cost Method:**

The travel cost method is used to estimate the value of recreational benefits generated by ecosystems. It assumes that the value of the site or its recreational services is reflected in how much people are willing to pay to get there. It is referred to as a “revealed preference” method, because it uses actual behaviour and choices to infer values. Thus, peoples’ preferences are revealed by their choices.

The basic premise of the travel cost method is that the time and travel cost expenses that people incur to visit a site represent the “price” of access to the site. Thus, peoples’ willingness to pay to visit the site can be estimated based on the number of trips that people make at different travel costs. This is analogous to estimating peoples’ willingness to pay for a marketed good based on the quantity demanded at different prices.

The travel cost method can be used to estimate the economic benefits or costs resulting from:

- changes in access costs for a recreational site;
- elimination of an existing recreational site;
- addition of a new recreational site;
- changes in environmental quality at a recreational site:

The travel cost method is relatively uncontroversial, because it is modeled on standard economic techniques for measuring value, and it uses information on actual behaviour rather than verbal responses to hypothetical scenarios. It is based on the simple and well-founded assumption that travel costs reflect recreational value. It is often relatively inexpensive to apply.

**HEDONIC PRICING METHODS:**

**Overview:**

The hedonic pricing method is another technique to determine environmental value. In its earliest applications, these techniques were intended to capture the willingness-to-pay measures associated with variations in property values that result from the presence or absence of specific environmental attributes, for instance, air pollution, noise, or water views. By comparing the market value of two properties which differ only with respect to a specific environmental attribute, economists may assess the implicit price of that amenity (or its cost when undesirable) by observing the behaviour of buyers and sellers.
A variation on the approach of comparing the effects of an environmental attribute would involve comparing the price of a single piece of property over successive sales. By correcting for other factors that might influence the value of the subject property, economists are able to isolate the implicit price of some amenity or bundle of amenities which have changed over time. The price of a house may be affected by factors such as the number of bedrooms, the square footage, and the existence of a pool, the proximity to local schools, shopping, and highways. The price may also be affected by the proximity to, or quality of, environmental amenities. Air quality has been found to be a determinant of housing prices in Los Angeles; whether or not a property abuts woodland may also matter. Hedonic methods can also be used to estimate the effect of certain disamenities on the price of a house, for instance, the impact on the price of a residential property adjacent to an area affected by a spill or some proposed unfavorable development.

The process for estimating an hedonic price function that relates housing prices to the quantities of various characteristics is reasonably straightforward. However, it is much more difficult to derive value measures from these estimated functions. Only under very restrictive assumptions can values be obtained directly from these estimated functions. In most cases, a two-stage procedure that depends on information from multiple markets is necessary.

Advantages of This Technique:
The hedonic techniques, like travel cost and random utility models depend on observable data resulting from the actual behaviour of individuals. Market data on property sales and characteristics are available through real estate services and municipal sources and can be readily linked with other secondary data sources.

Disadvantages of This Technique:
Most environmental incidents will have only small, if any, effects on housing prices. Even where effects do exist, it may be difficult to estimate them using econometric methods because many factors, many of which are correlated, influence housing prices. For example, a house located near a factory with emissions that reduce air quality may be in a poorer section of town where schools are not as good and there are few other amenities like parks. Even when implicit prices for environmental amenities can be estimated, it is usually very difficult to obtain measures of value from these models. The connection between the implicit prices and value measures is technically very complex and sometimes empirically unobtainable.

Data Needs:
Data needs include prices and characteristics of houses sold in the housing market of interest. In particular, a measure or index of the environmental amenity of interest is needed.

Summary of the Hedonic Pricing Method:
The hedonic pricing method is used to estimate the value of environmental amenities that affect prices of marketed goods. Most applications use residential housing prices to estimate the value of environmental amenities. The method is based on the assumption that people value the characteristics of a good, or the services it provides, rather than the good itself. Thus, prices will
reflect the value of a set of characteristics, including environmental characteristics that people consider important when purchasing the good.

The hedonic pricing method may be used to estimate economic benefits or costs associated with:

- environmental quality, including air pollution, water pollution, or noise:
- environmental amenities, such as aesthetic views or proximity to recreational sites:

The hedonic pricing method is relatively straightforward and uncontroversial to apply, because it is based on actual market prices and fairly easily measured data. If data are readily available, it can be relatively inexpensive to apply. If data must be gathered and compiled, the cost of an application can increase substantially.

**Applying the Hedonic Pricing Method Using Housing Prices:**

In general, the price of a house is related to the characteristics of the house and property itself, the characteristics of the neighborhood and community, and environmental characteristics. Thus, if non-environmental factors are controlled for, then any remaining differences in price can be attributed to differences in environmental quality. For example, if all characteristics of houses and neighborhoods throughout an area were the same, except for the level of air pollution, then houses with better air quality would cost more. This higher price reflects the value of cleaner air to people who purchase houses in the area.

To apply the hedonic pricing method, the following information must be collected:

- A measure or index of the environmental amenity of interest.
- Cross-section and/or time-series data on property values and property and household characteristics for a well-defined market area that includes homes with different levels of environmental quality, or different distances to an environmental amenity, such as open space.

The data are analyzed using **regression analysis**, which relates the price of the property to its characteristics and the environmental characteristic(s) of interest. Thus, the effects of different characteristics on price can be estimated. The regression results indicate how much property values will change for a small change in each characteristic, holding all other characteristics constant.

The analysis may be complicated by a number of factors. For example, the relationship between price and characteristics of the property may not be linear – prices may increase at an increasing or decreasing rate when characteristics change. In addition, many of the variables are likely to be correlated, so that their values change in similar ways. This can lead to understating the significance of some variables in the analysis. Thus, different functional forms and model specifications for the analysis must be considered.
DIRECT TECHNIQUES:
CONTINGENT VALUATION METHOD (CVM)

Overview:
The most obvious way to measure nonmarket values is through directly questioning individuals on their willingness-to-pay for a good or service. Called the contingent valuation method, it is a survey or questionnaire-based approach to the valuation of non-market goods and services. The monetary values obtained for the good or service are said to be contingent upon the nature of the constructed (hypothetical or simulated) market and the good or service described in the survey scenario.

The contingent valuation technique has great flexibility, allowing valuation of a wider variety of non-market goods and services than is possible with any of the indirect techniques. It is, in fact, the only method currently available for estimating nonuse values. In natural resources, contingent valuation studies generally derive values through the elicitation of respondents’ willingness-to-pay to prevent injuries to natural resources or to restore injured natural resources. Since the first published contingent valuation study on valuing outdoor recreation appeared in 1963, more than 1,400 related documented papers, reports, and books have been published.

In contingent valuation methods, randomly selected samples or stratified samples of individuals selected from the general population are given information about a particular problem. They are then presented with a hypothetical occurrence such as a disaster and a policy action that ensures against a disaster; they are then asked how much they would be willing to pay- for instance, in extra utility taxes, income taxes, or access fees- either to avoid a negative occurrence or bring about a positive one. The actual format may take the form of a direct question ("how much?") or it may be a bidding procedure (a ranking of alternatives) or referenda (yes/no) vote. Economists generally prefer the referenda method of eliciting values since it is one most people are familiar with. The resulting data are then analyzed statistically and extrapolated to the population that the sample represents.

Contingent valuation studies are conducted as face-to-face interviews, telephone interviews, or mail surveys. The face-to-face is the most expensive survey administration format but is generally considered the best, especially if visual material needs to be presented. Non-response bias is always a concern in all sampling frames. In other words, people who do not respond have, on average, different values than people who do respond.

A Sampler of Contingent Valuation Questions:

Suppose that the Ghodaghodi Tal (a wetland of western Nepal) were to disappear tomorrow and that persons like you had a chance to save this particular area. What would you reasonably estimate to be the maximum you would be willing to pay each year (RS.) in order to guarantee the use of this area for you and your household?

<table>
<thead>
<tr>
<th>0-50</th>
<th>200-250</th>
<th>450-500</th>
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<td>50-100</td>
<td>250-300</td>
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<td>100-150</td>
<td>300-350</td>
<td>550-600</td>
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</table>
How Do We Use the Results?

From the analysis, the researchers can estimate the average value for an individual or household in the sample, and extrapolate this to the relevant population in order to calculate the total benefits from the site. For example, if they find that the mean willingness to pay is Rs10 per capita, the total benefits to all citizens would be Rs 50,000. (assuming that population is 5,000)

Advantages of This Technique:
In principle, contingent valuation methods can be used to estimate the economic value of anything, even if there is no observable behaviour available to deduce values through other means. It is the only method that has any hope of measuring “existence values,” i.e., the value that individuals place on simply knowing the natural resource exists in an improved state. This is because since existence values are not connected with use and all other methods depend on observing actual behaviour associated with the resource.

Though the technique requires competent survey analysts to achieve defensible estimates, it is not difficult to understand. The responses must be statistically analyzed, but require no more than the understanding of a mean or median value.

Disadvantages of This Technique:
When conducted to the exacting standards of the profession, contingent valuation methods can be very expensive because of the extensive pre-testing and survey work. In addition, while this technique appears easy, its application is fraught with problems, for example, the possibility of strategic bias by respondents or structural problems in questionnaire design. Moreover, question framing, mode of administration, payment formats, and interviewer interactions can all affect results.

Many questions have been raised about the reliability of the contingent valuation method for the calculation of nonuse values particularly in regard to natural resource damage assessment.

Data Needs:
The quality of a contingent valuation questionnaire depends upon the amount of information that is known beforehand about the way people think about the resource in question. Information on who uses the resource and who knows about it are critical. When the contingent valuation method is applied to use values, the economist undertaking the survey will want to sample populations most likely to use the resource. The key point is that while all the information necessary for assessing an individual's value of the resource is collected in the survey, the economist needs help in identifying a representative sample and information to allow extrapolation to the population.
Summary of the Contingent Valuation Method:

The contingent valuation method (CVM) is used to estimate economic values for all kinds of ecosystem and environmental services. The method has great flexibility, allowing valuation of a wider variety of non-market goods and services than is possible with any other non-market valuation technique. It can be used to estimate both use and non-use values, and it is the most widely used method for estimating non-use values. It is also the most controversial of the non-market valuation methods.

The contingent valuation method involves directly asking people, in a survey, how much they would be willing to pay for specific environmental services. In some cases, people are asked for the amount of compensation they would be willing to accept to give up specific environmental services. It is called “contingent” valuation, because people are asked to state their willingness to pay, contingent on a specific hypothetical scenario and description of the environmental service.

The contingent valuation method is referred to as a “stated preference” method, because it asks people to directly state their values, rather than inferring values from actual choices, as the “revealed preference” methods do. It circumvents the absence of markets for environmental goods by presenting consumers with hypothetical markets in which they have the opportunity to pay for the good in question. The hypothetical market may be modeled. The fact that contingent valuation is based on what people say they would do, as opposed to what people are observed to do, is the source of its greatest strengths and its greatest weaknesses. Contingent valuation is one of the only ways to assign monetary values to non-use values of the environment-values that do not involve market purchases and may not involve direct participation. These values are sometimes referred to as “passive use” values. They include everything from the basic life support functions associated with ecosystem health or biodiversity, to the enjoyment of a scenic vista or a wilderness experience, to appreciating the option to fish or bird watch in the future, or the right to bequest those options to your grandchildren. It also includes the value people place on simply knowing that giant pandas, whales or rhino exist.

It is clear that people value non-use, or passive use, environmental benefits. However, these benefits are likely to be implicitly treated as zero unless their monetary value is somehow estimated. So, how much are they worth? Since people do not reveal their willingness to pay for them through their purchases or by their behaviour, the only option for estimating a value is by asking them questions.

However, the fact that the contingent valuation method is based on asking people questions, as opposed to observing their actual behaviour, is the source of enormous controversy. The conceptual, empirical, and practical problems associated with developing monetary estimates of economic value on the basis of how people respond to hypothetical questions about hypothetical market situations are debated constantly in the economics literature. CV researchers are attempting to address these problems, but they are far from finished. Meanwhile, many economists, psychologists and sociologists, for many different reasons, do not believe the monetary estimates that result from CV are valid. More importantly, many jurists and policymakers will not accept the results of CV. Because of its controversial nature, users must be
extremely cautious about spending money on CV studies and about using the results of CV studies, after either a private goods market or a political market.

**Pros and Cons of Contingent Valuation:**

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
</tr>
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<tbody>
<tr>
<td>1. Based in economic utility theory and can produce reliable estimates.</td>
<td>1. Estimates of nonuse values are difficult to validate externally.</td>
</tr>
<tr>
<td>2. Most biases can be eliminated by careful survey design and implementation.</td>
<td>2. Stated intentions of willingness to pay may exceed true feelings.</td>
</tr>
<tr>
<td>3. Currently the only method available to measure important nonuse values associated with natural resources.</td>
<td>3. Results may appear inconsistent with tenets of rational choice</td>
</tr>
<tr>
<td>4. Has been used successfully in a variety of situations.</td>
<td>4. Respondents may be unfamiliar with the good or service being valued and not have an adequate basis for articulating their true value.</td>
</tr>
<tr>
<td>5. Is being constantly improved to make the methodology more reliable.</td>
<td>5. Respondents may express a value for the satisfaction (&quot;warm glow&quot;) of giving rather than the value of the goods or service in question.</td>
</tr>
<tr>
<td>6. Respondents may fail to take questions seriously because the financial implications of their responses are not binding.</td>
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</tbody>
</table>

4.5.1 Option value:

The option value of a resource or amenity reflects the value we would give to our potential or optional future use of the resource or amenity. For example, we may consider our local park would be a good place to start playing cricket on the weekends, which would increase our overall future use of the park and therefore our value of it.

4.5.2 Existence value:

The existence value is the value which reflects our willingness to pay for a resource or asset to be preserved simply because we wish for it to continue to exist. In the case of our park regardless of current use value and future option value, we would also wish it to continue to exist because of the aesthetic and ambience it provides to the area.
4.5.3 Use value:

The Use Value is the value we consider a resource or amenity to currently have in reference to our current use of it. For example, we may value a park based on walking a dog around it, playing football one evening per week, and having picnics on it during the summer months.

\[ \text{TEV} = \text{Use Value} + \text{Option Value} + \text{Existence Value} \]

: End of this unit:

UNIT: 5  
Project Formulation and Evaluation:

Meaning of project:

A project is a time-bound intervention consisting of a set of planned and interrelated activities executed to bring about a beneficial change. It has a start and a finish, involves a multidisciplinary team collaborating to implement activities within constraints of cost, time and quality, and has a scope of work that is unique and subject to uncertainty. Projects link policy initiatives at a higher level (e.g., national or sectoral) with a specific problem faced by a target group of local-level stakeholders or by institutions or organizations.

Project formulation:

The process of designing a project consists of rejecting and accepting alternatives for executing a job (which is a constituent of the project) and evaluating each phase by applying the same principles. The best alternatives for each of the numerous jobs needed to achieve the objectives(s) are then combined to form the project. In the ideal sense, a good project is a package of a number of interwoven and highly dependent jobs each being the most desirable alternatives for securing the purpose. Most desirable here refers to the least costly or socially most acceptable and profitable means of achieving the objectives. These all processes towards the project activities accepting a particular project are basically known as project formulation.

Summary about project formulation:

(Adapted from the FAO guide)

<table>
<thead>
<tr>
<th>Phases</th>
<th>Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Preparation of project formulation.</td>
<td>Concerns all activities necessary to prepare for sound formulation of the project. It has two step. 1. Project inception. 2. Preparation of formulation work plan.</td>
</tr>
<tr>
<td>2. Reconnaissance and preliminary project design.</td>
<td>3. Analysis/diagnosis of the situation from an overall perspective. 4. Analysis/diagnosis of the situation from the perspective of the main interest groups involved. 5. Assessing the future without project.</td>
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<td>6.</td>
<td>Outline specification of a possible project.</td>
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<tr>
<td>3.</td>
<td>Project design.</td>
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<td></td>
<td>7. Detailed technical and socio-economic investigation.</td>
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<td></td>
<td>8. More precise definition of project objectives, targets, and design criteria.</td>
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<td></td>
<td>9. Design of individual project components.</td>
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<td>10. Design of project organization, structure, and management arrangements.</td>
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<td></td>
<td>11. Project cost and revenues estimation and first financing proposal.</td>
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<tr>
<td>4.</td>
<td>Analysis of project results.</td>
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<td></td>
<td>12. Financial analysis.</td>
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<td></td>
<td>15. Environmental impact analysis.</td>
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<tr>
<td>5.</td>
<td>Project documentation and submission.</td>
</tr>
<tr>
<td></td>
<td>Concerns all activities necessary to prepare a final project document, complete with design and relevant analysis.</td>
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<tr>
<td></td>
<td>16. Project documentation and submission.</td>
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<tr>
<td>6.</td>
<td>Project negotiation.</td>
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<td>Concerns all activities necessary to have the project document accepted, and project financed for implementation. It starts when the source of financing accepts the project formulation document. The work includes only one principal step, namely:</td>
</tr>
<tr>
<td></td>
<td>17. Project appraisal and negotiation.</td>
</tr>
<tr>
<td></td>
<td>The output is a project fully ready for implementation, under proper administration, and with the necessary financial commitments.</td>
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</tbody>
</table>

**Project identification:** Phase 1 and 2:
**Project preparation:** Phase 3, 4 and 5
**Project appraisal:** phase 6

**5.1 Stage of project formulation:**
Project formulation is a cyclic process, starting from the pre-investment stage and ending at post-investment stage through the investment stage.
5.1.1 Pre-investment stage:
Pre-investment is the initial stage of project formulation which includes following activities:

- Identification:
- Preparation and feasibility:
- Market aspect:
- Technical aspect:
- Financial aspect:
- Economic aspect:
- Operational aspect:
- Project appraisal:
  - Net present value:
  - Benefit cost ratio:
  - Land expectation value:
  - Internal rate of return (Economic rate of return and financial rate of return)
- Source of financing:

5.1.1.1 Identification:
The first important task in pre-investment stage is to identify with precision the problem objective or goal of project. This will in turn depend on regional/ state/ national/ international priorities. The area in which the project is to function is identified. This may base on following aspects.

- The need for the project in the area.
- Availability of required inputs in the area.
- Backwardness of the area etc.

For the purpose of identification frequently a separate sector survey of the current situation will indicate what initiatives are needed. Such survey may be under taken with the help of an agency (may be national or international) or by using existing team. In case of forest related project the survey will examine the current status of project, the future needs of such types of project and consider programmes to improve the quality of rural life. The survey will probably generate
suggestions about new areas for investment and the relative priority to the given different initiatives.

5.1.1.2 Preparation and feasibility:

Once project is identified, there begins a process of progressively more detailed preparation and analysis of project plan. The project must be socially acceptable, environmentally sound, economically viable and operationally feasible. This process includes all the works necessary to bring the project to the point at which a careful review or appraisal can be under taken and even implementation. In project preparation and feasibility generally includes three phases, which are project design, analysis of expected results and project documentation and submission.

**Project design:**
The project design phase normally initiates the formal project preparation stage. It typically follows five steps namely:

a. Detailed technical and socio-economic investigations are undertaken.
b. More precise definition of project objectives, targets, and design criteria are determined.
c. Design of individual project components performed.
d. Design of project organization, structure, and management arrangements are made.
e. Project cost and revenues estimation and first financing proposal prepared.

The output of the design phase is a full description and costing of the project, together with a proposed financing plan.

**Analysis of expected results:**
This concerns all activities necessary to assess project results in terms of output, effects, and impact on the sector, and in any other sectors they may affect in some way. Its starting point is usually the project design report, which provides the basis for the analysis. The work basically contains four steps namely:

a. Financial analysis.
b. Economic analysis.
c. Social analysis.
d. Environmental impact analysis.

The output of the phase is the determination of effects and impacts of the project.

**Project documentation and submission:**
This phase concerns all activities necessary to prepare a final project document, complete with design and relevant analysis. In this phase project documentation and submission work is carefully done. The output of the phase is project document.

5.1.1.3 Market, Technical, Financial, Economic, Operational aspect:
During preparation and analysis of project different aspects should be considered. These aspects include;

**Market aspect:**
- Search for the market of the product or service so produced by the project.
- The arrangement for the supply of inputs needed to build and operate the project.
- Arrangements for the procurement of equipment and supplies.

**Technical aspects:**
- Whether the project is technically possible to conduct.
For example in case of forestry project, the technical aspect concerns with the soil, water, tree species, plants and animals, production, supply nearby market etc.

**Financial aspect:**
Financial aspect is primarily concerned with costs and benefits directly associated with a project, firm or program. Financial analysis should be carried out to estimate the returns on an investment, to make sure the firm/project has adequate cash flow at any time to carry out its business/activity (e.g. salaries, creditors, debtors, taxes etc.). A cost or a benefit is included in a financial evaluation only if the cost or benefit affects the cash flow and the project bottom line. Costs and benefits are valued at the market price at the date they occur and discounted to the present if this occurrence is in the future.

**Economic aspect:**
Economic aspect includes every accountable item in a financial valuation plus any costs and benefits which do not affect financial results but affect or will affect positively or negatively the wider economy e.g. air and noise pollution costs, CO2 emissions. Economic analysis should be carried out while preparing the project.

**Operational aspect:**
Whether it is possible to operate the project with regard to impact on the ecology and environment, local socio-economic impact, financial implications, availability of human resources etc. should be analysed.

5.1.1.4 Appraisal: NPV, Benefit Cost ratio, Land expectation value, IRR-Economic Rate of return and financial rate of return:
Appraisal is a process in which it's likely success or otherwise is evaluated before actual implementation. Project appraisal is done in away, that the following virtues are examined:
- Impact on the local and regional socio-economy.
- Contribution to development.
- Justification for use of scarce land, human, financial and other resources.
- Generation of employment.
- Impact on the environment.
- Likely outputs and also the term over which they would be available.
- Cost effectiveness analysis.
- Benefit cost analysis.

**Net present value:**
Also called,
DCF - Discounted cash flow.
PNW - Present net worth.
The NPV is the algebraic sum of the discounted costs and revenues at a specified interest rate. In formula form;

\[ NPV = \sum_{t=0}^{n} \left( R_t - C_t \right) \frac{1}{(1 + i)^t} \]

Where,
NPV = Net present value:
R_t = The revenue or positive cash flow in year t.
C_t = The cost or negative cash flow in year t.
t = The year in which the cash flow occurs.
\( i \) = The interest rate, usually the alternative rate of return or the cost of capital.

The project which has higher NPV is acceptable than the project which has lower NPV.

<table>
<thead>
<tr>
<th>If...</th>
<th>It means...</th>
<th>Then...</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV &gt; 0</td>
<td>the investment would add value to the firm</td>
<td>the project may be accepted</td>
</tr>
<tr>
<td>NPV &lt; 0</td>
<td>the investment would subtract value from the firm</td>
<td>the project should be rejected</td>
</tr>
<tr>
<td>NPV = 0</td>
<td>the investment would neither gain nor lose value for the firm</td>
<td>We should be indifferent in the decision whether to accept or reject the project. This project adds no monetary value. Decision should be based on other criteria, e.g., strategic positioning or other factors not explicitly included in the calculation.</td>
</tr>
</tbody>
</table>

Working formula while calculating NPV:
1. 
\[ V_0 = \frac{V_n}{(1 + i)^n} \]
Where,
\( V_0 \) = the present value of single payment.
\( V_n \) = the future value of a single payment in year n.
\( i \) = the interest rate.
n = the years in which the payments occurs.

2. The future value of terminating annual annuity.
(A series of payments, all the same amount, were made at regular intervals for a specified numbers of time periods are called terminating annual annuities)
Forest economics, SFM 454

\[ S_{An} = a \cdot \frac{(1 + i)^n - 1}{i} \]

Where,
- \( S_{An} \) is the future value of a terminating annuity or equivalently, the sum of annuities at year \( n \).
- \( a \) is the amount of the annuity.
- \( n \) is the number of years the annuity is paid.
- \( i \) is the interest rate.

3. The present value of a terminating annual annuity.

\[ S_{A0} = a \cdot \frac{(1 + i)^n - 1}{i(1 + i)^n} \]

Where,
- \( S_{A0} \) is the present value of a terminating annuity or equivalently, the sum of the annuities in year \( 0 \).
- Others are as equation -2.
- These formulas are also necessary while computing IRR.

**Benefit cost ratio:**
A project's benefit cost ratio is the net present value of benefits divided by net present value of the cost.

\[
\frac{B}{C} \text{ ratio} = \frac{\sum_{t=0}^{n} B_t}{\sum_{t=0}^{n} (1 + i)^t} \div \frac{\sum_{t=0}^{n} C_t}{\sum_{t=0}^{n} (1 + i)^t}
\]

According to \( B/C \) ratio criterion, Projects are acceptable when \( B/C \) ratio is 1 or greater than 1 and unacceptable if \( B/C \) ratio is lesser than 1.

**Land expectation value \((L_e)\):**
Also called,
- Faustmann formula
- Land rent \((L_r)\)
- Soil rent \((S_r)\)
- Soil expectation value \((S_e)\)

"If a price of land is expected to provide a continual net income of \( X \) rupees periodically, then the land can be valued at a sum, which at an acceptable rate of interest gives the same periodical income of \( Rs \ X \); that value is known as land expectation value.

\[ L_e = \frac{V_0 \times (1 + i)^n}{(1 + i)^n - 1} \]

Where,
- \( L_e \) is the land expectation value:
V₀ = the present value of a perpetual periodic annuities that will be received every n years.
n = the numbers of years between annuities payments.
I = the interest rate.

Hence, land expectation value is nothing more than a special case of NPV that has certain restrictive assumptions made about it. These are:
1. Land value is zero.
2. The land has no residual stand.
3. The land is forested in perpetuity. (In the case of forest management project)
4. The cash flow from the forest will be the same in perpetuity. (In case of forest management project)

**Calculation of Land expectation value : (in case of forest management)**
- Choose an interest rate- usually given in the problem
- Calculate NPV without land value and with regeneration costs.
- Determine the perpetual periodic annuity- which is equal to NPV without land.

**Computing formula:**

\[
L_e = NPV \text{ without land} \times \frac{(1 + i)^n}{(1 + i)^n - 1}
\]

**Decision criterion:**
- If Lₑ is greater than market price land is brought.
- If market price is greater than Lₑ land is not brought.

**Internal rate of return:**
In more specific terms, the IRR of a project is the discount rate at which the net present value of costs (negative cash flows) of the project equals the net present value of the benefits (positive cash flows) of the project.
IRR also called:
ROI- Return on investment:
ROR- Rate of return:
MEC- Marginal efficiency of capital:
MPC- Marginal productivity of capital:
IRR is the interest rate that equalizes the present value of the costs and revenues. It is the value of i that causes the following equation to be true.

\[
\sum_{t=0}^{n} \frac{R_t}{(1 + i)^t} = \sum_{t=0}^{n} \frac{C_t}{(1 + i)^t}
\]

Or,

\[
\sum_{t=0}^{n} \frac{R_t}{(1 + i)^t} - \sum_{t=0}^{n} \frac{C_t}{(1 + i)^t} = 0
\]
Or,
\[ \sum_{t=0}^{n} \frac{(B_t - C_t)}{(1 + i)^t} = 0 \]

Where,
- \( R_t \) = the revenue or positive cash flows in year \( t \).
- \( C_t \) = the costs or negative cash flows in year \( t \).
- \( t \) = the year in which the cash flows occurs.
- \( i \) = the interest rate when above equation is true and is the IRR.

**Decision criterion:**

If the IRR is greater than the cost of capital, accept the project.

If the IRR is less than the cost of capital, reject the project.

**Computation of IRR**

- At first choose highest positive NPV.
- Then choose immediate negative NPV.
- Perform interpolation as formula given below.

\[ IRR = LR + \left[ \left( \frac{LNPV}{LNPV - HNPV} \right) \times (HR - LR) \right] \]

Where,
- \( IRR \) = internal rate of return:
- \( LR \) = lower interest rate (Which gives maximum positive NPV)
- \( HR \) = higher interest rate (Which gives immediate negative NPV)
- \( LNPV \) = NPV in lower interest rate (Positive)
- \( HNPV \) = NPV in higher interest rate (Negative)

**Note:** While computing IRR by interpolation, it is desirable to keep difference of interest rate 1, for the purpose of more accurate IRR.

**Economic rate of return:**

ERR is the IRR, while considering all factors of projects, eg. all financial factors and social factors are considered while computing the IRR. Probable social factors are valued in financial term and then added up to the financial factors.

**Financial rate of return:**

FRR is the IRR, only considering the financial factors of a project. In FRR all social factors are ignored.
5.1.1.5 Financing:
Availability and arrangements of funds is one of the most important parts of project formulation. It is necessary that funds are available as and when required. It is not enough to ensure adequacy of long term capital resources. The success of the project also depends on ready availability of short term or working capital resources. Major sources of finance for forestry or other development projects are: central and local government, credit from international agencies like world bank, ADB, and IMF etc, and aid from international donor agencies and foreign countries etc.
Financing is analogous to demand for capital in capital budgeting. Hence the following general principles of estimating the earnings of capital expenditure should be adopted while financing the project.
- Earning of each project should be estimated separately.
- Though the sources of earning may vary from project to project, the two most important sources of earning viz, cost saving, sales expansion or added profits must be taken into account.
- For estimating future earnings, profit projections must be based on future prices and costs.
- Not only the actual earnings, but also the opportunity cost of an investment should be taken into account.
- The stream of capital earning in distant future must be appropriately discounted to know its present value, particularly in the case of long-term projects.
- While assessing the earnings of comparison, an average of invested capital per time unit should be used, instead of initial capital outlay.
- Productivity of capital should be estimated on the basis of earnings over the life-time of the assets less cost of the investment (ie. total wastage of capital).
- Estimated earnings must be adjusted on account of the indirect contribution of the proposed investment to the existing production facility, though it may be very difficult task, and may involve a large margin of error.

5.1.2 Investment and design:
Key task: verify the validity of each aspect of project formulation stage:
In this stage two aspects of project implementation, under proper administration, and the necessary financial commitments are determined.

5.1.2.1 Project Implementation
Implementation is the stage where all the planned activities are put into action. Before the implementation of a project, the implementers (spearheaded by the project committee or executive) should identify their strength and weaknesses (internal forces), opportunities and threats (external forces). The strength and opportunities are positive forces that should be exploited to efficiently implement a project. The weaknesses and threats are hindrances that can hamper project implementation. The implementers should ensure that they devise means of overcoming them. Monitoring is important at this implementation phase to ensure that the project is implemented as per the schedule. This is a continuous process that should be put in place before project implementation starts. As such, the monitoring activities should appear on the work plan and should involve all stake holders. If activities are not going on well, arrangements should be made to identify the problem so that they can be corrected. Monitoring is also
Important to ensure that activities are implemented as planned. This helps the implementers to measure how well they are achieving their targets. This is based on the understanding that the process through which a project is implemented has a lot of effect on its use, operation and maintenance. When implementation of the project is not on target, there is a need for the project managers to ask themselves and answer the question, "How best do we get there?"

Hence following two points should be considered in the project implementation design.
- Preparing for time schedules for all jobs so that the physical and financial targets of the project are phases appropriately.
- Distributing works to various departments or agencies having the appropriate technical expertise.

There are two aspects of project implementation, namely, the sequence of main implementation phases, and problem area of different stages of implementation. Implementation is described by further succession of phases containing a number of steps. However, projects differ considerably, the process may be differing but a general project may take following phases.
- Recruiting human resources.
- Studies and engineering.
- Construction and procurement.
- Start-up of Field operation.
- Standardization of Field Operation and achievement of project goals.
- Termination of the project component.

**Problem areas at different stage:**
- Institutional problem:
- Conceptual problem:
- Technical problem:
- Financial problem:
- Social problem:
- Political problem:
- Environmental problem:

### 5.1.3 Post investment stage:
Evaluation criterion and terms and reference should be determined on the project document.
- On-going evaluation: This is carried out during implementation.
- Mid-term evaluation: This is carried out after completion of the time.
- Terminal evaluation: It is carried out the completion of the project.
- Ex-post evaluation: This is carried out some year after project completion when projects benefits are be fully realized.

The provision of such types of evaluation techniques should be incorporated while preparing the project documents.

### 5.1.3.1 Operation and evaluation:
This includes;
- Executing and controlling the project which requires frequent reviewing, updating the activities and constant action to restore the operation to its planned characteristics.
• Evaluating the performance of each project/programme involving the experts, of the related field to ensure the worth of good and service for each rupee spent.

5.2 Project evaluation:
Evaluation is a process of determining or systematically measuring the effects and impacts of the projects as envisaged in its objectives. This is also an organizational process of improving activities still in progress or assisting for future planning and decision making.
For the purpose of evaluation may be classified as;
- Evaluation plan- which is prepared with project formulation stage and incorporated in project document.
- Evaluation action- which is done in project implementation stage and after sometime later of the project completion as prescribed in evaluation plan of the project document.

5.2.1 Meaning and method:
- On-going evaluation – This is carried out during implementation.
- Mid-term evaluation- This is carried out after completion of half of the time.
- Terminal evaluation – it is carried out at the completion of the project
- Ex-post evaluation – This is carried out some year after project completion when project benefits are expected to be fully realized.

Evaluation objectives:
- Provide guidance during project implementation.
- Provide guidance for future project planning and implementation
- Assess achievement of overall results of the projects in terms of efficiency, outputs, effects and impact.

5.2.2 Cost effectiveness analysis:
- Cost effectiveness analysis (CEA) is a technique for selecting among competing wants wherever resources are limited.
- CEA was first applied to clinical service in the mid 1960s.
- CEA is a technique for comparing the relative value of various strategies
- A new strategy is compared with new practice:
  Cost (new strategy) – Cost (current practice)
- CEA ratio =  
  Effect (new strategy) – Effect (current practice)

5.2.3 Planning programming and budgeting:
- The project planning, programming and budgeting is a method used to document and track project needs and risk of associated unfunded activities
- The core of 3PB is the activity data sheet
- The activity data sheet contains all project needs that provides output to the various planning and review process that occur during the fiscal year
- 3PB involves input and output processes
5.2.4 Benefit cost analysis its use and limitation:

- Benefit-cost analysis is most commonly used method for project appraisal.
- Once project costs and benefits are identified, these costs and benefits are converted to present value.
- It gives efficiency of per unit of cost investment

Use of BCA

- It helps in reducing differences in the marginal effectiveness of alternative measures for accomplishing such objectives as between irrigation and other means of raising agricultural production.
- It helps in assessing the costs of fulfilling one objective in terms of benefits sacrificed with respect to others.
- It has a political advantage in that, it would be difficult for any particular group to distort project plans to serve its own interests.
- It permits decentralized decision making. Even if the public sector is small, no single authority can hope to handle the vast mass of technical information needed to decide on a number of specific projects. In order to calculate costs and benefits of each project, a separate authority is needed for each. This, therefore, necessitates decentralization of decision making.
- It is a practical way of assessing the desirability of projects, where it is important to take a long view (in the sense of looking at repercussions in the future, as well as the near future) and a wide view (in the sense of allowing for side effects of many kinds on many person, society, region etc.)

Limitations:

- B-C analysis places too much emphasis on monetary units, however, valuation of environmental aspect is rather complex.
- B-C has been criticized because they often blind to issues of environmental equity and fail to make explicit who bears the cost of the projects and who reaps the benefit.
- Difficult in cost assessment: mainly due to market imperfection, use of shadow prices.
- Difficult in benefit assessment too; due to uncertainty regarding future price, demand and supply.
- Arbitrary discount rate: Social rate of discount is likely to be arbitrary.
- Neglects joint benefits and costs.
- Ignores opportunity costs.
- Adjustment for risk and uncertainty.
- The problem of externalities: difficult to measure.

5.2.5 Socio economic and political impact:

- Impact is consequential results of the effect and final outcome of the project.
• It is the change in the condition of beneficiaries
• Some level of impact may emerge during implementation, e. g. increased employment
• But full impact would accrue only after the full development of the project.

**Different effect and impact may be:**
• Impact on net National value addition.
• Effect on employment.
• Effect on distribution.
• Effect on foreign exchange.
• Effect on infrastructure.
• Effect on overall environment.
• Impact on livelihood.

5.2.5 **Risk and Uncertainty in Forest investment: Risk management, decision making with uncertainty.**

There are three different conditions under which decisions are made.

- **Certainty:**
  - Certainty exists if there is only one outcome for each alternative. Stated differently, the outcome for each alternative is known; thus, choosing the alternative automatically defines the outcome.

- **Risk:**
  - Risk exists if a probability distribution can be attached to the different states of nature and hence to the different outcomes. The state of nature cannot be predicted for each occurrence but the number of times each state of nature will occur if the decision is made frequently can be predicted. The probability distributions can come from different sources. They may be based on historical evidence and records or they may be obtained subjectively by asking experts for their opinion about the likelihood of state of nature occurring.

- **Uncertainty:**
  - Uncertainty exists if there is no information about the probability distribution of the states of nature. This means that not even a subjective estimate of the probabilities can be made by experts.

**Future is always uncertain:**
• Farmers – few months to harvest crop.
• Industrial investors – a return within few years.
• But forester’s effort materialize (may not) after decades – even centuries.
The uncontrollable and unpredictable factors operating over a forest rotation presents so horrifying a prospect that many foresters ignore them altogether. But this is inexcusable and irresponsible. There are techniques that help to predict the trend of relevant economic and political variables.

Sources of risks and uncertainties faced by forestry:
1. Natural environment – climate hazards, biotic – insects, pathogens, browsing animals.
2. Technological – new inventions (sawmill in Chaubas).
3. Human factors – accidental fires, illicit felling, encroachment.
4. Market – unexpected surges and collapses (e.g., taxus).
5. Political milieu – changes of government, wars, policy and taxation.

Decision making with uncertainty:

Decision models for decision making with uncertainty usually require developing a decision or payoff matrix. We will use the decision matrix in the table given below, which contains the outcomes for several alternatives and states of nature. The matrix indicate that if alternative A₁ is chosen a loss of 12 units will occur for for states of status S₁, a loss of 8 units for states of S₂ and a loss of 2 units for states of S₃.

The minimax criterion, also called the maximin:
• Minimise the chance of maximum loss.
• The worst possible outcome under each alternative and the least objectionable alternative form among these is chosen.
• The worst possible outcomes in the decision matrix are A₁ =12, A₂ = 7, and A₃ = 15 of S₁, S₂ and S₃ respectively.
• Hence A₂ is chosen because this is where possible loss is minimized.

The minmin criterion, also called the maximax criterion:
• It minimizes the minimum payoff.
• It implicitly assumes only the best possible outcomes will occur and picks the best among them.
• The criterion is to choose the best possible outcome for each alternative and then to choose the alternative with the best among these.
• The best outcomes in the decision matrix are S₃ for A₁ (loss = 2), S₂, and S₃ for A₂ (loss = 5) and S₁ for A₃ (loss = 0)
• The criterion instructs one to pick A₃ because this has the least loss that is the highest payoff.

Hypothetical decision matrix:

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>States of nature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S₁</td>
</tr>
<tr>
<td>A₁</td>
<td>12</td>
</tr>
<tr>
<td>A₂</td>
<td>7</td>
</tr>
<tr>
<td>A₃</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Thompson (1970)
Decision making with risk (risk management):

- In case of decision making with risk the minimax regret criterion may be used.
- This criterion incorporates the idea of opportunity cost into the decision making process.
- Minimum loss value for each state is subtracted from the payoff to compute the regret for each alternative for this state.
- The maximum amount of regret for each alternative is identified in the following table by block and italic fashion.
- $A_2$ is chosen as the as the course of action because it has the minimum amount of regret.

Decision matrix for minimax regret criterion:

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>States of nature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S_1$</td>
</tr>
<tr>
<td>$A_1$</td>
<td>12-0 = 12</td>
</tr>
<tr>
<td>$A_2$</td>
<td>7-0 = 7</td>
</tr>
<tr>
<td>$A_3$</td>
<td>0-0 = 0</td>
</tr>
</tbody>
</table>

"END OF THIS UNIT"

UNIT: 6 WELFARE ECONOMICS:

Welfare economics is the branch of economics established in the 20th century that seeks to evaluate economic policies in terms of their effects on the community's well-being. Early theorists defined welfare as the sum of the satisfactions accruing to an individual through an economic system. Believing it was possible to compare the well-being of two or more individuals, they argued that a poor person would derive more satisfaction from an increase in income than would a rich person. Later writers argued that making such comparisons with any precision was impossible. A new and more limited criterion was later developed: one economic situation was deemed superior to another if at least one person had been made better off without anyone else being made worse off.

Welfare economics is a branch of economics that uses microeconomic techniques to determine the allocation efficiency within an economy and the income distribution associated with it. Welfare economics is concerned with welfare of individuals because individual is the basic unit of measurement. It also assumes that individuals are the best judges of their own welfare. Social welfare refers to the overall state of society. It is often defined as the summation of welfare of all the individuals in the society.

6.1 Externalities:

In economics, an externality, or transaction spillover, is a cost or benefit that is not transmitted through prices or is incurred by a party who was not involved as either a buyer or seller of the goods or services causing the cost or benefit. The cost of an externality is a negative externality,
or external cost, while the benefit of an externality is a positive externality, or external benefit.

In the case of both negative and positive externalities, prices in a competitive market do not reflect the full costs or benefits of producing or consuming a product or service. Producers and consumers may neither bear all of the costs nor reap all of the benefits of the economic activity, and too much or too little of the goods will be produced or consumed in terms of overall costs and benefits to society.

For example, air pollution due to manufacturing imposes costs on the whole society, while fireproofing a home improves the fire safety of neighbors. If there are external costs such as pollution, the good is overproduced by a competitive market, as the producer does not take into account the external costs when producing the good. If there are external benefits, such as in areas of education or public safety, too little of the good would be produced by private markets as producers and buyers do not take into account the external benefits to others. Here, overall cost and benefit to society is defined as the sum of the economic benefits and costs for all parties involved.

Example:

Negative externalities:

A negative externality (also called "external cost" or "external diseconomy") is an action of a product on consumers that imposes a negative side effect on a third party; it is "social cost".

- Air pollution from burning fossil fuels causes damages to crops, (historic) buildings and public health.
- Anthropogenic climate change is attributed to greenhouse gas emissions from burning oil, gas, and coal.
- Water pollution by industries that adds poisons to the water, which harm plants, animals, and humans.
- Noise pollution is mentally and psychologically disruptive.
- The harvesting by one fishing company in the ocean depletes the stock of available fish for the other companies and overfishing may be the result. The stock fish is an example of a common property resource, and that, in the absence of appropriate environmental governance, is vulnerable to the Tragedy of the commons.
- There is evidence that crime in a neighborhood increases after the opening of liquor store. Liquor stores may draw an undesirable class of citizens into the neighborhood to shop and hang out. They may also cause more people in the area to drink; such people may then proceed to commit acts in the neighborhood that they would not normally do, or else these drunken people may become easy targets for the crimes of others. Even if the crimes start out small, they may eventually become much worse if not effectively
addressed (broken windows theory). Liquor stores are more likely to be open late into the night than other stores, and may result in increased noise levels which harm property values in the community.

Positive externalities

Examples of **positive externalities** (beneficial externality, external benefit, external economy, or **Merit goods**) include:

- Increased **education** of individuals can lead to broader society benefits in the form of greater economic **productivity**, lower unemployment rate, greater household mobility and higher rates of political participation.

- A **beekeeper** keeps the **bees** for their **honey**. A side effect or externality associated with her activity is the **pollination** of surrounding crops by the bees. The value generated by the pollination may be more important than the value of the harvested honey.

- An individual planting an attractive garden in front of his or her house may provide benefits to others living in the area, and even financial benefits in the form of increased property values for all property owners.

- A public organization that coordinates the control of an infectious disease preventing others in society from getting sick.

A common solution to providing positive externalities is taxation. A tax requires everyone to pay for a beneficial service, such as **police** and **fire protection**, which eliminates the **free rider problem**.

**6.2 Public goods:**

Public good is a good that is non-rivalries and non-excludable. Non-rivalry means that consumption of the good by one individual does not reduce availability of the good for consumption by others; and non-excludability that no one can be effectively excluded from using the good.

Non-rivalness and non-excludability may cause problems for the production of public goods. Some economists argue that the nature of public good lead to instances of market failure, where uncoordinated markets driven by parties working in their own self interest are unable to provide these goods in desired quantities.
Forest economics, SFM 454

Type of goods and their properties

<table>
<thead>
<tr>
<th>Level of Exclusivity</th>
<th>Exclusive:</th>
<th>Non-exclusive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rival</td>
<td>Private land based goods:</td>
<td>Common property goods:</td>
</tr>
<tr>
<td></td>
<td>- Commodity production</td>
<td>- Lake, river system</td>
</tr>
<tr>
<td></td>
<td>- Mineral extraction</td>
<td>Public forest</td>
</tr>
<tr>
<td>Level of Rivalry</td>
<td>Club goods:</td>
<td>Purely public goods:</td>
</tr>
<tr>
<td>Non Rival</td>
<td>Resorts</td>
<td>- Aesthetics</td>
</tr>
<tr>
<td></td>
<td>Golf courses</td>
<td>- Sun-sets</td>
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</tbody>
</table>

**Free rider problem:**
Public goods provide a very important example of market failure in which market-like behavior of individual gain-seeking does not produce efficient results. The production of public goods results in positive externalities which are not remunerated. If private organizations don't reap all the benefits of a public good which they have produced, their incentives to produce it voluntarily might be insufficient. Consumers can take advantage of public goods without contributing sufficiently to their creation. This is called the free rider problem.

- Non-excludable – can’t stop those who don’t pay from using a good
- Non-rival – one person’s consumption of the good doesn’t stop others from enjoying it
- No profit based incentive for production because of ‘free-riding’

**6.3 Pigouvian theory:**

In a very simple way, Pigouvi an solution prefers to use government intervention to solve externality.

**In detail:**

Pigouvi an theory is based on the method of modern economics especially based on welfare economics; and Pigouvi an theory provides a perspective systematic study of the externality problems.

According to Pigouvi an theory the marginal private net output and marginal social net output has following relationships: Besides the increasing of marginal private benefits, if other people can still get benefit from the private activities, then the marginal social net benefit is greater than the marginal private net benefits; on the other hand, if other people’s benefit is decreasing due to the
private activities, then the marginal social net output is less than the marginal private net output. In the first situation the society will get the “Marginal social benefit”; in the second situation the will face the “Marginal social cost”.

Actually, Externality is caused by the inconsistency between marginal private cost and marginal social cost. Without externality, the marginal private cost of production or consumption of an item is equal to the cost of itself. When there are negative externalities, there will cost to compensate these externalities.

By adding marginal private cost with the marginal external cost we will get the marginal social cost. On the other hand, when there are positive externalities, the benefits which generated by business activities are not fully occupied by the company, but will also become some external social benefits. Through economic model, Pigou shows that because of the presence of external economic effects, the Pareto optimal allocation of social resource cannot be achieved by purely individualistic mechanism.

Since there is a deviation among the marginal private benefit and marginal social benefit, marginal private cost and marginal social cost; therefore the maximization of social welfare cannot be achieved only through free competition. The Government should take appropriate economic policies to reduce this deviation as much as possible. The proper policy is that: when the marginal private cost is less than marginal social cost (negative externality), government should impose taxes; when the marginal private benefit is less than marginal social benefits (positive externality) then the government should provide incentives and subsidies. Pigou believes that by using such taxes and subsidies, the externality problem could be internalized. And such policy is known as Pigouvian solution, and the tax is called Pigouvian tax.

Pigouvian solution has been widely used. In the field of infrastructure, the policy is who invest who benefits; in the environmental protection, the policy is who pollute who pay (Polluter Pays Principle PPP).

**Pigou’s dual criteria for determining the social welfare:**

- **First criteria:** Given the supply of factors of production social welfare increases with the increase in national income. National income is the sum of the market value of final goods and services produced by normal residents of the country in an accounting year. Thus increasing national income results in more satisfaction from more goods which increase in social welfare.
- **Second criteria:** Social welfare increases when transfer of real income from the rich to poor increases (but the transfer does not lead to decrease in national income).

**Criticism:**

Pigou defines social welfare as the aggregate of utilities derived by the individuals in the society. As the concept of utility is subjective, it cannot be added and thus definition of social welfare is
unrealistic. As the value of money keeps on changing, using money as a tool to measure economic welfare may be inaccurate.

6.4 Pareto optimality:
The concept of Pareto-optimal or Pareto-efficient is based on the criterion given by Italian economist Vilfredo Pareto. According to him, a situation is defined as Pareto-optimal (or efficient) if it is impossible to make anyone better-off without making someone worse-off. The Pareto’s optimality criterion states that any changes that make one member of the society better-off without making someone worse-off is an improvement in social welfare. Conversely, if any changes make at least one member of the society worse-off without making any member better-off, then it is decrease in social welfare. In order to attain Pareto-efficient situation, the following three conditions need to be satisfied:

Three conditions

Condition 1: Efficiency in production: it means the efficient allocation of factors of production among the firms.

Condition 2: Efficiency in exchange of consumption it means the efficient distribution of commodities among the consumers.

Condition 3: Efficiency in product mix or composition of output it means the efficient allocation of factors among commodities.

Criticism

The criteria considered only those changes that make anyone better off without making someone worse-off. It does not take into account those changes that make few people better-off by making few people worse off.

1. As each point on the curve is Pareto-efficient, there are infinite numbers of points which are Pareto-optimal. These various points are not comparable unless interpersonal comparison and value judgments are made.

2. Pareto-optimality is necessary but not sufficient conditions for the welfare maximization. In other words, a situation may be Pareto-optimal without maximizing social welfare. Thus this criterion does not ensure the maximization of social welfare.

6.5 Investment in natural resources and its development in Nepal:

- Forests, water and soils are main Natural resources in Nepal
- Resources are of two types, renewable and non renewable
- Forest resources are renewable resources
- Forests resources are depleted because of common pool nature
- Forestry investment is a long term investment
- Forest and water are associated with land value.
- Land value can be assessed in terms of fertility and assessibility.
  Nepalese government initiated forest resource management with the assistance of foreign donor

- Any transaction that increases the real capital and yield additional income is known as investment.
- Any entrepreneur before investing has to think over three things:
  - cost of capital
  - prospective yield from the life time of the capital assets
  - Rate of interest
- According to Keynes, investment rate in the economy is mainly influenced by the two factors
  - Marginal efficiency of capital
  - Interest rate
- Marginal efficiency of capital means its productivity efficiency, shows possible income from the additional capital investment.
- Interest rate is an opportunity cost of money to any investment decisions

**How to Invest and develop:**

"THE END"