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AND
CONTINUING EDUCATION

Natural Resources

M.SC. ENVIRONMENT STUDIES

MANONMANIAM SUNDARANAR UNIVESITY
TIRUNELVELI

Natural Resources

PAPER V

NATURAL RESOURCES

UNIT 1 Definition, classification and conservation, land use pattern, land use planning, watersheds, reservoirs, forestry, fisheries, land minerals, mineral maps, precious metals, rare earths.

1. Definition

Resources occurring in nature is a substance, material, energy unit which man can be utilized to create wealth. Examples include oil, coal, water, land, flora, fauna etc.

2. Classification of Natural Resources

1. Complex resources
2. Simplex biotic resources
3. Recycling resources
4. Non-recycling resources
5. Renewable resources
6. Non-renewable resources
7. Unconditionally renewable resources
8. Conditionally renewable resources
9. A biotic flow resources
10. A biotic cycling resources

3. Conservation

The term conservation means the total protection or restriction in consumptive use of resources. Wild life conservation means a total ban on killing of any animal. The term, in fact is derived from two Latin words – con (together) and servare, (to keep together). Conservation also means the management or human use of the biosphere so that it may yield the greatest sustainable benefits to present generation, while maintaining its potential to the needs and aspirations of future generations. Conservation is the practice embracing preservation, maintenance, sustainable utilization, restoration and enhancement of the natural environment. About one – half of the world's species may already have been lost. This has prompted the protection of at least 10 percent of the total land area in each country or in each ecosystem, so as to double or triple the land area now designated as national parks or biosphere reserves.

Some general desirable attributes of conservation measure are outlined below:

1. They must be firmly grounded in the discipline of natural sciences, but should also involve other disciplines such as social sciences, humanities, law, education and economics.

2. They should be implemented at several scales of time and space.
3. They should aim to harmonize species-oriented and ecosystem-oriented approaches.
4. They should take into account biological attributes and processes at all levels of the biological hierarchy.
5. They should work across national, cultural and ecological boundaries.
6. They should strive to address local community development and conservation needs in an integrated manner.

4. Land use pattern

The pattern of land-use of a country at any particular time is totally determined by its physical, economic and institutional framework. In other words, the existing land-use pattern in different regions of a country evolved as a result of the action and interaction of various factors, such as the physical characteristics of land, the institutional framework, the structure of other resources (capital, labour, etc.) available and the location of the region in relation to other aspects of economic development. The present pattern can, therefore, be considered to be in some sort of static harmony and adjustment with the other main characteristics of the economy of the region. In the dynamic context, keeping in view of the natural endowments and the recent advances in technology, the overall interests of a country may dictate a certain modification or change in the existing land – use pattern of a region. A close study of the present land-use patterns and the trends during recent years will help to suggest the scope for planned shifts in the patterns.

Out of the total geographical area of 328 million hectares, the land-use statistics are available for roughly 306 million hectares, constituting 93 percent of the total. The arable land was estimated to be 161.3 million hectares or 52.7 percent of the total reporting area. Around 65.9 million hectares or 21.6 percent of the total area was under forests. Land put to non-agricultural uses was estimated to be 16.1 million hectares (5.2 percent of the total) and the barren and unculturable land was 30.2 million hectares or 9.9 percent of the reporting area. Permanent pastures and other grazing land were estimated to be 13 million hectare. The cultivable wasteland forms another 15.2 million hectares or 5 percent.

The land area, for which data on the land-use classification are available, is known as the “reporting area”. The land-use classification figures given above are based on land records. The reporting area is according to village papers or records maintained by the village revenue agency and the data are based on a complete enumeration of all the areas. In some cases, village papers are not maintained. Therefore the estimates of the area under different classes of land are based on the sample survey or other methods to complete the coverage. The reporting area is the aggregate of the areas based on these two methods. The areas for which no statistics are available are called “non-reporting area”. The whole of the reporting area is neither completely surveyed nor completely covered by enumeration of sample surveys. There are pockets of areas in a few states for which only “ad-hoc estimates” are prepared. Of the total geographical area, only 80.7 percent is cadastrally surveyed. Of the cadastrally surveyed areas, 91.4 percent has a permanent reporting agency, whereas 8.6 percent has no reporting agency.

The land area in India was classified into five categories known as the five-fold land utilization classification. These categories are:

1. Forests
2. Area not available for cultivation
3. Other uncultivated land, excluding the current fallows
4. Fallow lands
5. The net area sown.

This five-fold classification however indicates a very broad outline of land-use in the country and was not found adequate enough to meet the needs of agricultural planning in the country. The states were also finding it difficult to present comparable data according to this classification owing to the lack of uniformity in the definitions and scope of classification covered by these five broad categories. To remove the non-comparability and to break up the broad categories into smaller constituents for better comprehension, the Technical Committee on Co-ordination of Agricultural Statistics, setup by the Ministry of Food and Agriculture, recommended a nine-fold land-use classification replacing the old five-fold classification. It also recommended standard concepts and definitions for all the states to follow. The statement below gives the nine-fold classification and its relationship with the old five-fold classification.

No	Old Classification	New Classification
1	Forests	Forests
2	Area not available for cultivation	Land put to non-agricultural uses
3	Other cultivated land, excluding	Barren and unculturable land current fallows
4	Fallow lands	Permanent pastures and other grazing lands
5	Net area sown	Miscellaneous tree crops and groves, not included in the net area sown • Culturable waste • Fallow land other than current fallows • Current fallows • Net area sown

The total of these classes under both classifications adds up to the reporting area. The revised classification has been accepted in principle by most of the states. In West Bengal, the data are still presented on the basis of the old classification only.

The above land-use classification is primarily based on whether a particular area is cultivated, grazed or forested. Its main purpose is to show the distribution in detail of the existing land according to its actual use and not how a particular piece of land can be potentially utilized. Thus, the area under culturable waste land does not represent the area which is really culturable, as it may not be possible to bring under cultivation large part of the area, without involving huge cost. Thus the potential land-use classification is faced with several difficulties, as this classification would depend upon the suitability of different areas for different uses, taking into account their natural endowments, the

availability of capital and other resources for the development of land for the desired use and likely economic returns. If the potential use of the land has to be taken into account, a large amount of data relating to the inherent characteristics of each soil type and the economics of putting it to a particular use would have to be specially collected through soil surveys, land-use surveys and waste land utilization surveys.

On the basis of the nine-fold classification, indicated above it is possible to revise the old five-fold classification as well as to arrive at the area according to concepts like 'arable land' or 'potential land' available for crop husbandry. The 'arable land' indicates the 'net area shown' plus the 'current fallows' and 'other fallow land'. Similarly, the 'potential land' available for cultivation would includes 'arable land', the land considered as 'culturable waste', 'permanent pastures grazing land', and miscellaneous tree crops and groves, not included in the net area sown. However, the land characteristics cannot be ascertained without making a comprehensive soil survey and land use study. The utility of the above concepts of 'arable' and 'potential' land can be understood better if some indicators of arable and potential land are computed:

$$\text{Percentage potential land exploited} = \frac{\text{net area sown}}{\text{potential land}} \times 100$$

$$\text{Percentage arable land exploited} = \frac{\text{Net area sown}}{\text{arable land}} \times 100$$

With the adoption of the nine-fold classification since 1950-51 an element of non-comparability has been introduced in the data before and after that year. For instance, the former Bombay State adopted the old land-utilisation classification in which, the term 'current fallows' means land lying fallow for a period of ten years where as in former Punjab state it is two years. In the revised nine-fold classification, the current fallows have been limited to the land lying fallow for more than one year, but less than five years. Thus the area under 'current fallow' in the old five-fold classification need not necessarily be divided into two sub classes in the new classification, i.e. 'current fallows' and 'other fallow land'. Some of the land lying fallow beyond five years may have been included in the nine-fold classification as 'culturable waste'.

In many countries, there is considerable scope for bringing new areas under cultivation. In India the scope for extension of cultivation to new lands is very limited. Already, about 49.7 percent of the total reporting area is cultivated. Culturable land, which is not cultivated at present (culturable waste land other fallow lands, permanent pastures, grazing lands and miscellaneous tree crops), is estimated to be 42 million hectares or 13.6 percent of the total. Most of this area is occupied by marginal and sub-marginal lands, and the extension of cultivation to this area will be costly, as it requires extensive works for soil and water conservation, irrigation and reclamation.

After studying the type of soil, rainfall, natural vegetation, etc. suitable reclamation measures are suggested for bringing the areas under cultivation. In addition, wherever necessary, resettlement schemes needed for keeping the areas under cultivation

are also proposed. Suitable cropping patterns for various areas and the economics of reclamation in respect of these areas were discussed. Finally, priorities were indicated to improve the reclaimable lands. With regard to the data on culturable waste lands, the committee observed that land classified as culturable waste at the time of settlement sometimes continued to be shown as such in the revenue records long after they had come under cultivation. In the opinion of the committee, the mere collection of statistics under the head 'culturable waste' served no purpose and detailed information about the type of wasteland in each state, the ownership of such land, its availability in sizable blocks and the cost of reclamation measures should be indicated. The committee, therefore, recommended that rapid surveys should be conducted for collecting such information. The committee further recommended a survey and categorisation of wastelands in blocks measuring less than 100 hectares. For this purpose, several schemes were taken up by different state governments during the Third Plan.

Taking into account the total land resources, including hills, mountains, lakes, rivers and lands of all descriptions, the availability of land per head in India comes to only 0.58 hectare as compared with the availability of 59 hectares per head in Australia, 45.07 hectares in Canada, 9.06 hectares in the U.S.S.R, 4.48 hectares in the U.S.A, 2.33 hectares in Burma, 1.21 hectares in Pakistan, 0.43 hectare in U.K. and 0.35 hectares in Japan. It is clear that the availability of land per head in India is among the lowest in the world. This is a natural corollary to the population explosion.

5. Land use planning

Land is one of the most important components of the life support system which has been overused and even abused over the centuries.

Nobody can afford to neglect the most important natural resource. This is not simply an environmental problem but one which is basic to the future of our country. The stock question before us is whether our soil will be productive enough to sustain a population of one billion by the end of this century at higher standards of living than that now prevail. We must have long-term plans to meet this contingency.

In a predominantly agricultural country like India the land use planning assumes priority. Good soil forms the basis and also the foundation of good farming and good living. An understanding of good farming begins with an understanding of the soil. Due to the high population, soil is used increasingly which poses threat to its productivity. In fact careless use can damage soil with consequent reduction in quality and quantity of forest, grassland and cropland. There will be soil erosion degradation of watersheds, denature of catchments; deforestation, and desertification. This type of problems shall have bearing on the stability of the rural life.

Land is a finite resource and therefore it is very essential to handle the land in a planned way so that the demands are met in an integrated fashion. We therefore need a national policy on land and soil with short and long range objectives. Our land use statistics are indeed confusing and there is therefore, an urgent need for a detailed land survey so that its use is related to its quality thereby avoiding improper utilization, which caused considerable degradation.

The present official land use statistics are indeed very confusing. Thus the first and foremost requirement is a sound database with a reliable 1:1 million scale soil maps of the country. A time bound nation-wide survey programme of micro-level land use planning may be taken up with district, or a village, as the basic unit, giving short and long term operations. This would enable to apportion land for short-term and long-term requirements for agriculture, forestry, permanent vegetation, grasslands, fisheries, water bodies, water sheds, water resources, human settlements, roads, transport, industries, mining, brick kilns, defense needs, flood plain, and harbours keeping in view of the soil quality, local factors and site specificity. The planning process shall have to be in an integrated fashion-taking note of the requirements in relation to the escalating population.

Such a survey will yield information on land use classes which need to be given precise definition. These would include apportioning land, keeping in view of the projected demands for various land use indicated above. In turn, it would also lead to land suitability evaluation and soil capability, classification based on detailed soil characteristics, climate, topography, vegetation and socio-economic considerations. This would be possible only if we evolve a comprehensive land use policy, both short and long term to fulfill the socio-economic objectives of the country.

All existing legislations on the subject need to be reviewed and updated so that unwarranted change in land use does not take place. This should be particularly true to change the land use from agricultural to non-agricultural operations

A dynamic land use policy has to be evolved expeditiously to ensure minimum and inescapable diversion of agricultural and forest land to other uses.

6. Water sheds

Water is an integral part of land or soil productivity base and its misuse can cause both soil degradation and erosion. Therefore, management of water on sound lines is necessary for the general well-being of all life, including the people and crop yields. For maintaining good living standards we need ample water resources .

Availability of water in a given soil environment is a critical factor and is related to erosion, situation, loss of beneficial plant cover and productivity. Agricultural production from land mainly relies on water management, rainfall and resultant runoff. Such management can best be based on a natural unit called watershed. A watershed is an area bounded by the divide line of water flow so that a distinct drainage basin of any small or big watercourse or stream can be identified. The rain falling over this area will flow through only one exit point of the whole water shed .In other words the area will be drained only by one stream or water course. This pocket of water can be assessed and analysed for making plans for the optimum utilization, through ground water wells, tube wells, small farm ponds, bigger tanks or reservoirs and diversion of lift irrigation schemes.

7. Reservoirs

Reservoir is a component of earth's surface water management structure. Reservoir receives the surface water runoff (and may be some ground water seepage). This water get accumulated in a low level, relative to the surrounding area.

A reservoir is a manmade lake that is created when a dam is built on a river. River water backs up behind the dam forming a reservoir.

The earth has many freshwater lakes ranging from fishing ponds to Lakes. Most lakes have fresh water, but some, especially those where water cannot escape through a river, become salty. In fact, some lakes, such as the Great Salt Lake, are saltier than the oceans. Most lakes support considerable aquatic life. Lakes formed by the erosive force of ancient glaciers, such as the Great Lakes, is more than thousand meter deep. Some very large lakes are shallow - Lake Pontchartrain in Louisiana has a maximum depth of 5 meters.

Some of the salty lakes were formed in ancient times when they were connected to seas and when rainfall may have been heavier. These lakes have been shrinking since the last ice age.

8. Forestry

Geographical area of India is around 3.3 million sq. km in which forest area is 0.79 million sq. km constituting 24 percent of the total geographical area. Forests are one of the most striking features of the land surface. Certain forests are evergreen like the Deodar forests of Kashmir, while others are deciduous becoming leafless either before the advent of winter when vegetative activity almost ceases or just before the onset of intense dry summer to reduce transpiration like the teak forest of the Central India.

Forests play a very important role in the life and economy of a country. Due to deforestation, the stability of many ecological sub-systems have been disturbed. Once the forest cover is damaged, severe soil erosion takes place disturbing the entire eco-system, checking the dams and reservoirs with silt load and there by promoting the recurrence of floods.

Forestry is the art and science of creating, maintaining and appraising the forest resources with the object of producing goods and services on a sustained basis for the welfare of mankind and its environment. Forestry is thus a conscientious use of the land for economic and social well being of the society. It also deals on the practice of managing forestland and its associated resources.

The forest products are classified under two headings:

1. major products
2. minor products

Timber pulp, match wood, round wood, firewood, charcoal wood etc. form the major product. Minor forest products comprise of bamboos, canes, fodder grass, gums, resins, lac, drugs, spices, dye stuff, seeds, tender leaves, honey etc.

The following basic services and economic returns are expected from our forests:

1. Provide fuel and fodder for the rural masses particularly the poor landless and marginal peasants / tribals and their domestic animals free of cost or at a very low cost.
2. Provide timber of average quality for rural dwellings. For rural artisans for making tools, implements, boats etc. to support rural vocations and economy.
3. Provide high quality timber and some fuel for the urban population.
4. Maintain a steady supply of raw materials needed for paper making, plywood and other forest based industries.
5. Continue to function effectively as conservator of soil, climate and environment.
6. Promote wild life and bird life to maintain ecological balance.

Forests are classified into different categories for the convenience of description, administration, management and record. Forest in India are classified based on their geographical and climatic distribution, functional areas etc.

Forests according to their geographical and climatic distribution are classified into four types. They are tropical, montane subtropical, temperate and alpine.

The basic requirement for the development of a wasteland is the creation of a suitable vegetative cover, which not only prevents further degradation but also improves the environment. On waste lands, if a green cover with grasses, legumes, shrubs and trees is established and maintained and cutting and grazing are prohibited, the land gradually recover by itself and may eventually even become productive. The choice of plant species for reclamation and afforestation of any type of wasteland should be such that it should suit the local conditions and grow normally with least attention.

Two tree species suitable for the reclamation of degraded and wastelands are *Albizia lebbeck, Casuarina equisetifolia.*

9. Fisheries

Oceans, lakes and rivers cover four fifths of the earth's surface. The Indo-West Pacific Ocean is having rich biodiversity containing an estimated 1500 species against 280 species is having rich biodiversity of fish in Eastern Atlantic.

Fish capturing ,processing and trading have provided food, employment and income to coastal and inland communities for centuries. Fish contribute substantially to the world supply of animal protein, either directly or through their use as foodstuff for

livestock. Almost a third of the fish catch is converted into meal and oil. The developing countries produce more than half of the world's fish catch. Their fisheries are dominated by small scale or artisanal producers.

During this century, demand for fish and fishery products is expected to exceed by 20 million tones. The production capacity estimated to be at 100 million tones of fish are now destroyed by the indiscriminate capture operations.

Fish stocks are a renewable resource and many of them are over exploited. Moreover the aquatic ecosystem is degraded due to pollution or competing uses. The oceans function as a sink for carbon-di-oxide, eroded soils, contaminants, fertilizers and human and industrial wastes. The development of intensive aquaculture has, in some cases, damaged coastal ecosystems and water resources, causing conflicts over land use and resources. Mismanagement may and even undermine local sources of employment and food.

10. Minerals

Minerals are classified based on their composition e.g. silicates, carbonates, oxides. Silicates are by far the most abundant mineral group. The rock cycle is relevant to the study of minerals and gemstones because it explains how they are formed. Minerals form at different points of the cycle.

Rock of continental crust

1. Erosion, transport, deposition
2. Sediment
3. Sedimentary rock
4. Metamorphic rock
5. Igneous rock

The rock cycle shown above operates in an anticlockwise direction.

The products of erosion, transport and deposition become sedimentary rock (on a long time scale) after being subjected to pressure by compaction. Then metamorphism may occur (rocks are altered by heat and or pressure) there may be chemical reactions leading to the formation of metamorphic rock.

When metamorphic or sedimentary rocks subside they may reach depths at which internal processes can melt rock and convert it to magma. When this rises to the surface (via volcanoes) igneous rock is formed. If uplift occurs erosion, transportation and deposition begin again.

These processes are occurring throughout the course of earth's history. Minerals and gemstones are formed at different points on the cycle. Minerals and gemstones can be classified into groups depending on their chemical composition.

Quartz and silicates the largest group of minerals. They are metals combined with either silicon or silicate and oxygen. They are often igneous in origin. Silicate minerals can also be found in meteorites.

Calcites and carbonates occur abundantly in earth's surface. Calcites and dolomite occur as a result of the metal in combination with carbon and oxygen.

Minerals which consist of a metal/metals combined with sulphur and oxygen. Their chemical formula includes SO_4. Many are evaporates i.e. when salt water evaporates and leaves behind a mineral.

E.g. pyrrhotine, sulphides

Different experiments can be performed to determine:

i) Solubility in acids

1. Some minerals are almost completely insoluble
   E.g. gold
   Some are soluble in acid
   E.g. copper dissolves in nitric acid only.
2. Gases produced
   E.g. Sphalerite gives off a rotten egg smell when dissolved in hydrochloric acid, therefore indicating that it contains Sulphur.
3. Some minerals may give off chlorine.
4. Characteristics when placed in a flame

By placing minerals in a flame it may be possible to identify them. Firstly, some may melt entirely e.g. pyrite and some will not melt at all e.g. sapphire

Also different minerals give off different colour flames. However, chemical analysis is not very useful as a method of identification because it damages or destroys the sample.

11. Mineral map

India is endowed with rich mineral resources. With a history of mining activity dating back to the pre-Harappan period, it is today gearing to become a leading producer and exporter of a range of minerals.

For over 3000 years India was the only source of diamonds in the world. It can take pride in possessing the world's oldest zinc technology. The geological and metallurgical history of India is similar to those of the mineral-rich countries of Australia and South Africa and continents of South America and Antarctica, all of which formed a continuous landmass before the breaking up of Gondwanaland.

India has emerged as a leading producer of quite of few minerals, particularly industrial minerals. It is the world's largest producer of sheet mica and ranks third in the

production of coal, lignite and barites, fourth in iron ore, sixth in bauxite and manganese ore, 10th in aluminum land 11th in crude steel. It has stepped up the production of chromite and now has the third rank among the chromite producers.

Mineral exploration is carried out not only over the landmass but also offshore and on the seabed. India was granted the status of pioneer-investor by the United Nations in 1982 in seabed exploration. The country has secured an oil shore mining site spread over an area of about 1,50,000 sq. km in the central part of the Indian Ocean. This could yield 3 million tones each of copper and nickel, 80 million tones of manganese ore and half a million tones of cobalt.

The exploitation of the vast mineral reserves to meet the growing requirements for a variety of applications has therefore been a major economic activity, contributing significantly to the country's industrial development and export trade. Indicative of the significant strides made in this field over the past five decades is the increase in the mineral base from 34 in 1947 to 89 at present. Of this, four are fuel minerals, 11 are metallic, 52 are non-metallic and 22 are minor minerals. The total value of mineral production increased from Rs. 580 million on the eve of Independence to an estimated Rs. 6,19,210 million in 2002-03, excluding the atomic minerals. The production of metals is accounted far by iron ore, copper ore, chromite and/or zinc concentrates, gold manganese ore, bauxite and lead concentrates. Among the non-metallic minerals, more than 90 percent of the aggregate value is shared by limestone, magnesite, dolomite, barites, kaolin, gypsum, apatite and phosphorite, steatite and fluorite.

Two states, Chattisgarh and Jharkhand, account for 25 percent of the mineral production, and 10 states, namely Andhra Pradesh, Assam, Gujarat, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal and Karnataka, account for slightly less than 50 pecent of production. The remaining production, particularly of oil and gas, comes from offshore sources. Rajasthan, Chattisgarh, Orissa, Karnataka, Andhra Pradesh, Gujarat and Goa produce most of the metallic and non-metallic minerals, while Jharkhand, West Bengal, Orissa, Madhya Pradesh, Maharastra and Andhra Pradesh produce coal.

India has been a traditional exporter of minerals. Minerals and metals exports account for about 20 percent of total exports. There is potential for growth in exports and the increase in exploration and production resulting from enhanced private sector participation should help tap this potential optimally.

12. Precious metals

Precious metals are our most valued mineral resources. Gold is the most important of the group. Platinum and silver are other precious metals. Only around 18 percent of the total stock of 100000 tones of gold were mined so far. In the available gold 43 percent is held by banks and the rest is in private stocks. As of 1991, more than 83 percent of world gold consumption went into jewellery and 6 percent was used in medals and official coins such as the famous Canadian Maple leaf and South African Krugerrand. Another 6 percent was used in electronic equipment. Dental materials consumed 2.2 percent largely for crowns, which are required to presence the enamel.

The remaining 2.8 percent was consumed in a variety of industrial applications such as reflective coatings on glass and decorative gold foil for everything from plates to capital domes. Gold is also used in pharmaceuticals for the treatment of arthritis.

Placers have been the main source of gold for thousands of years, reflecting extremely high specific gravity of gold and its resistance to weathering. Many deposits exhibited the curious feature known as bedrock placer values in which gold was concentrated at the bottom of a thick layer of stream gravels. This probably happened when floods disrupted the entire layer, shaking down gold that was originally deposited throughout the sediment.

Gold is a very important by-product of many base-metal mines, particularly porphyrx copper deposits. Copper deposits were mined in such large volumes that their trace levels of gold (about 0.5 ppm or less) become economically important. The Bingham deposit produces almost 16 tones annually, more than double the production of the nearby Mercury gold mine, and similar amounts came from Ok Tedi and Grasberg in the Western Pacific.

Gold is recovered from ores by two main methods, both of which involve environmental concerns. Early recovery used amalgamation in which ore is mixed with mercury that selectively dissolves the gold and is then removed by evaporation. This approach, known as the patio process, was widely used during Spanish settlement of the New World. The cyanide process, which replaced amalgamation in the early 1900s' is based on the fact that precious metals form soluble complex ions with cyanide. Because cyanide will not dissolve quartz iron oxides and other common gangue minerals, it yields a relatively simple gold-bearing solution, which is known as a pregnant solution.

Although gold is produced in 67 countries, South Africa dominates in production, accounting for 30 percent of the total of production.

Gold differs from all other elements in its historical relation to money. It was the first metal used in coins. It gradually became dominant due to of its rarity, beauty, resistance to corrosion, and extreme malleability. In its purest form, the gold standard set the price for gold in the currency of the country and allowed free import and export of the metal. Thus the amount of money that a country could put into circulation was controlled by the amount of gold in its corporate banks, a powerful deterrent to inflation.

Silver

Silver occurs as sulfide argentite and also as several complex sulfide minerals containing lead, copper, antimony and arsenic. It is found in a wide variety of hydrothermal deposits as well as in a few placer deposits. It is a most important metal in three deposit types but it is more commonly a by-product. Silver by product comes largely from gold and base-metal deposits. In most of these deposits silver minerals form small inclusion in base metal sulfide minerals and they are difficult to separate.

Silver is produced from underground and open-pit mines. Silver is produced from 56 countries which includes the United States, Canada, Mexico and Peru. The United States is the major producer of silver. World silver reserves of 2,80,000 tons are

adequate only for 18 years of production at present rates and are highly dependent on by-product silver from lead-zinc and copper deposits.

The platinum-group of elements (PGE) which includes platinum, palladium, rhodium, ruthenium, iridium and osminium have identical chemical properties. Platinum and palladium are as scarce as gold and the other PGE's are even scarcer. Compared to gold and silver, the PGEs are identified later. Platinum was recognized as an element only in 1750. Osmium was discovered in 1844.

PGEs are produced from the Bushreld complex almost exclusively by underground mining. Most of these mines are working at depths of 500 to 1000 meters. Production pattern of PGE metal differs from operation to operation but always involves the separation of a concentrate containing sulfide minerals and PGEs.

PGEs are produced from 10 countries. Most platinum production comes from South Africa. Most palladium production is from Russia.

About 90 percent of world PGE reserves of 56,000 tons is from South Africa and Russia. In South Africa, much of the reserve is in deeper zones where mining will not be easier. Therefore latest processing methods are required.

The term indicator organisms refers to plants, animals or microbes which are indicators of ecological conditions. The species and morphology of plants growing in certain areas can provide valuable clues on the occurrence of minerals and metal bearing deposits beneath the surface. These are used for geo-botanical prospecting.

13. Rare earths

"Rare earths" is a general term. Lanthanides were originally extracted from rare minerals. But the elements themselves are not rare. Some are quite common. The wood earth means oxide, or a compound with oxygen.

The chemical properties of the rare earths, based on their matching valence electrons, are almost identical. They have slightly different atomic weights.

The rare earth elements are a relatively abundant group of 17 chemical elements composed of scandium and lanthanides.

The principal economic sources of rare earths are the minerals monazite. The elemental forms of rare earths are iron gray to silvery lustrous metals that are typically soft, malleable, and ductile and usually reactive, especially at elevated temperatures or when finely divided. The rare earth's unique properties are used in a wide variety of applications.

In chemistry, oxides of the rare earth metals. They were once thought to be elements themselves. They are widely distributed in the earth's crust and are fairly abundant, although they were once thought to be very scarce. Generally, the name of an earth is formed from the name of its element by replacing –um with – a; e.g. the earth of cerium is ceria. Mixed rare earths are used in glassmaking, ceramic glasses, glass-

polishing abrasives, carbon arc-light electrode cores, and catalysts for petroleum refining. Individual purified rare earths have many uses, e.g., in lasers and as color-television picture tube phosphors. Important rare-earth minerals include bastnasite, cerite, euxenite, gadolinite, monazite, and samarskite.

UNIT II Medicinal plants – endangered fauna and flora, ethno botanical importance tribal medicines, food crops, wild edibles, wild relatives of petro crops, timbers International Biological programme man and Biosphere, Nitrogen fixation

1. Medicinal plants

India is a vast country known for its traditional and cultural heritage. Plants in general are used for food, shelter etc. Certain plants are also used for curing different diseases. Such plants are called **Medicinal plants**. From time immemorial, traditional system of medicine such as Ayurveda, Unani and Siddha system is followed in India. In all these system of medicines, herbal plants are used for the preparation of drugs and it's derivatives. Around 30,000 species of medicinal plants have been in use by the indigenous societies and traditional healers world wide.

In India 7,500 species of medicinal plants are used by tribal societies and 500 species are used by Indian market like pharmaceutical industries, drug-processing institutes. Some of the important medicinal plants their distribution, occurrence, parts used and their disease curing nature are given below:

1. Glycyrrhiza glabra Linn (Paplionaceae)

1	Distribution	Himalayas, Kashmir
2	Parts used	Dried stem and roots
3	Chemical composition	Iso liquiritin is an important constituent of this plant. It also contains an estrogen steroid – Estrial. It is rich in glucose, sucrose, aspargin, resins and volatile oils.
4	Function or uses	It is used in the treatment of respiratory disorder, like bronchitis, asthma, cold and cough.
5	Modern uses	Nowadays it is used in the preparation of cough syrups and elexirs

2. *Piper longum Linn (Badi papal) Piperaceae*

1	Distribution	In warm regions of India
2	Parts used	Fruits
3	Chemical composition	❑ Alkaloid – piperine ❑ Oily compounds like Sesamine, Caryophyllene ❑ High content of calcium, phosphorus and iron
4	Function or uses	It is used in the treatment of respiratory disorder, like bronchitis, asthma, cold and cough.
5	Modern uses	Nowadays it is used in the preparation of cough syrups

3. *Terminalia chebula (Choti Har) Combretaceae*

1	Distribution	Throughout India
2	Parts used	Fruits
3	Chemical composition	Chebulin is an important compound present and a glycoside, similar to sennoside. It also contains high amount of tannins.
4	Function or uses	It is a valuable gift of nature. It is used as purgative, laxative to improve the functions of stomach and intestine. It is combined with amla (Emblica officinalis)
5	Modern uses	It cures stomach ailments

4. *Selaginella bryopteris (L.) (Sanjiwani) (Pteridophyte)*

1	Distribution	In the Himalayas and the Nilgiri Hills
2	Parts used	Whole plant with stem and leaves
3	Chemical composition	It contains glycerides and traces of alkaloids

4	Function or uses	It is referred as “Divine herb” used in earlier days to restore dead man back to life. It can restore vitality, agility and energy. It has tremendous cooling effects to the body. It controls any sort of urinary problems.

5. ***Centella asiatica (Linn) (Brahami buti) (Apiacea)***

1	Distribution	All over India
2	Parts used	Leaves
3	Chemical composition	They contain alkaloids, glycoside, organic acid. It contains rich amount of ascorbic acid. It also contains sugar, tannins, amino acids, glutamic acid, glycine, alanine and phenylalanine.
4	Function or uses	It is called as a “wonder drug” It is commonly called as Brahmi and has a excellent use in the traditional medicines as brain tonic and also for joint pains in athletes. It improves the mental power. It is also used in the treatment of skin, venereal diseases especially leprosy and syphilis.
5	Modern uses	It can induce fast growth of skin, hairs and nails. It is used as a tranquiliser, sedative and anti-amoebic. It improves the general ability and behavioural pattern of retarded children.

6. Gymnema sylvestre (Gurmar Buti) Asclepiadaceae

1	Distribution	All over India
2	Parts used	Leaves
3	Chemical composition	It contains anti-diabetic principles which destroys the power of sugar tasting
4	Function or uses	It is a wonder drug used in the treatment of diabetes
5	Modern uses	Researchers reveals that the plant extract rejuvenate the beta cells of the pancreas to produce insulin

7. Cassia angusitifolia (Senna leaves) Fabacea

1	Distribution	Mostly in South India
2	Parts used	Leaves
3	Chemical composition	It contains glycosides – Sennoside A and B other compounds like salicyclic acid, mannitol etc.
4	Function or uses	Senna is a "drug of choice" used in the treatment of gastro-intestinal disorders. It restores the proper function of stomach and intestine. Improves digestion and removes constipation
5	Modern uses	Recent investigations shows that sinnoside A and B have strong laxative action and improves the "peristalitic" movement of the human intestine.

8. Trichopus zeylanicus (Indian Ginseng)

1	Distribution	In peninsular India
2	Parts used	All parts
3	Function or uses	It is used to cure several ailments and provides vitality and agility to human body
4	Modern uses	Investigation of Tropical Botanical Gardern Research Institute (TBGRI) proves it has anti-fatigue effects on human body . It strengthens the immune system. It is commonly called "arogya pancha" meaning – cure for all diseases.

9. Aegle marmelos (L.) Correa (Wood apple) Rutaceae

1	Distribution	Throughout India
2	Parts used	All parts mainly fruits and leaves
3	Function or uses	It is considered as a "divine tree" having a excellent medicinal value. Fruits are used as "all cure" drug for stomach and intestinal problems. It cures chronic diarrhoea and dysentery. It increases the peristaltic movement of the intestine. Leaves when chewed with peper cures some kinds of tumours.

4	Modern uses	It has a great medical importance in treatment of cardio vascular diseases and in diabetes. It has excellent antibiotic properties (leaves, fruits and roots). Now-a days fruits are used for treatment of gastro-intestinal problems.

10. ***Azadirachta indica (Margosa) Meliaceae***

1	Distribution	Throughout India
2	Parts used	All parts are useful
3	Function or uses	It is a divine tree and called as "all cure drug". It is used in the treatment of piles and as a barrier of contraceptives. Margosa seed oil possesses antifertility activity. Unripe fruits and seeds has deworming properties. Ripe fruits are used in cough and eye diseases. Margosa oil is used for skin diseases and leprotic diseases. Bark soaked in water overnight reduces the blood sugar and also purifies the blood. Tender leaf reduces obesity if taken in early morning. Bark and leaf are used for the preparation of paste and powder, which is good for teeth and gums.
4	Modern uses	Investigations prove better results on the immuno-modulatory, contraceptive and anti-microbial activities of margosa oil. The antibiotic and antiseptic properties of these roots and leaves have been proved experimentally. Modern pharmaceutical companies produces margosa based solutions emulsions, tooth paste and soaps.

11. Sida rhombifolia Linn (Atibala) Malvaceae

1	Distribution	All over India
2	Parts used	Leaves and roots
3	Chemical composition	An important alkaloid is ephedrine.

4	Function or uses	It is used in rheumatic pain and also used in the treatment of pulmonary tuberculosis
5	Modern uses	Other 3 species of Sida are widely used in modern medical therapy. They are used in treatment of nervous and urinary disorders.

12. ***Moringa oleifera Lamk. (Drum sticks) Moringaceae***

1	Distribution	Throughout India
2	Parts used	Leaves, fruits and root bark
3	Function or uses	Fruits and seeds are used as vegetable and considered as a blood purifier. It is used in skin diseases and seed oil in eye problems.

13. ***Ricinus communis Linn. (Castor) Euphorbiaceae***

1	Distribution	Throughout India
2	Parts used	Leaves and seeds
3	Chemical composition	Ricin, lipase, ricinine, tripalmitin, proteins.
4	Function or uses	The oil from seed is used with milk as a strong purgative
5	Modern uses	It's oil is used to prepare contraceptive, jellies and creams. Leaves warmed and tied over the wounds cause healing in few days. Gel from the oil is used for skin diseases especially dermatitis and eczemas.

14. ***Calotropis procera (Aak) Asclepiadaceae***

1	Distribution	Throughout India
2	Parts used	All parts including latex.
3	Chemical composition	The milky latex contains calotropin. Roots contain calotropiol

4	Function or uses	Flowers and milky latex are used for various ailments. Leaf latex if applied on fresh cuts stops bleeding immediately. Relives the stomach ache and inhalation of burnt leaves cures headache.
5	Modern uses	Recent studies shows that the alkaloids present in it act as stimulant to heart.

15. ***Justicia adhatoda Syn Adhatoda vasica Nees (Basaka) Acanthaceae***

1	Distribution	Throughout India
2	Parts used	Fresh or dried leaves
3	Chemical composition	Contains alkaloid "vasicine" adhaatodic acid and essential oil
4	Function or uses	It is wonderful in curing respiratory problems. It softens the thick sputum.
5	Modern uses	Studies confirm that it has excellent property of testing as expectorant.

16. Phyllanthus niruri (Bhui-amla) Euphorbiaceae

1	Distribution	Throughout India
2	Parts used	Leaves, stem and roots (whole plant)
3	Chemical composition	Hypophyllanthin and alkaloid methoxynorsecurine
4	Function or uses	It is used in the treatment of Jaundice
5	Modern uses	It cures Hepatitis-B infection.

17. Aloe vera (L.) Burm (Kumaari) Lilaceae

1	Distribution	Throughout India
2	Parts used	Whole part
3	Chemical composition	Resins, mixture of polysaccharides containing pectic acid

4	Function or uses	It cures skin burns, cuts and wounds on the skin surface
5	Modern uses	Investigations reveals that extract of it, act on the dead epithelial cells of skin and helps in regaining cells and stimulates the growth of the new cells.

18. Ocimum sanctum Linn (sacred basil) Lamiaceae

1	Distribution	Throughout India
2	Parts used	Leaves and inflorescences
3	Chemical composition	Camphor
4	Function or uses	Leaf extracts is very effective in cold, cough and fever
5	Modern uses	Investigation confirms that decoction from the leaves, cures the infection of upper respiratory tracts. It is also effective in the treatment of ischemic heart diseases. It enhances the body resistance against stress

19. Albizza lebbek Linn (wild) Mimosoideae

1	Distribution	In dry regions of India
2	Parts used	Bark, leaves and seeds
3	Function or uses	It is used as a remedy for bronchitis, leprosy and gum inflammation. Leaves cures night blindness
4	Modern uses	Bronchial asthma are cured in 48 percent of the patients when 25 cc of bark decoction was used.

20. Asparagus adscendens (safed musli) Liliaceae

1	Distribution	In northern India
2	Parts used	Dried tuberous roots
3	Function or uses	It is used as a health tonic and for treating venereal diseases

2. Endangered fauna and flora

Conservation of plants is important to maintain the existence of life on the earth. Conservation of plants is needed in relation to the needs of agriculture, medicine and industry.

Endangered species are those plants and animals which are becoming extinct and the lives of many hundreds of species are threatened.

About 20,000 seed plant species of our plant are threatened because of increasing habitat pressures. To conserve the plant wealth it is better to preserve gene pools in germplasm.

The aims of conservation are:

1. Preserving the total range of plant populations
2. Ensuring the sustainable utilization of species and ecosystem, which supports the man.
3. Maintaining essential ecological process affecting human survival.

The international union for conservation of nature ICUN and natural resources have classified the endangered species into four groups.

1.	**Endangered (E.)**	**:**	Taxa in danger of extinction and their survival is unlikely if the casuality factor continue to operate.
2.	**Extinct (Ex)**	**:**	This category is used for species which are no longer known to exist in the world.
3.	**Vulnerable (V)**	**:**	Taxa believed to join the endangered category in the near future if the casuality factor continue to operate
4.	**Rare (R)**	**:**	Taxa with small populations that are not endangered at present or vulnerable but are at risk. These taxa are usually localized within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

Wild life is a renewable resource like soils, water and forests as it can be used in time and again without being destroyed and there is a great need of conservation of these renewable resources.

Wild life management is an important branch of conservation and it remains chiefly concerned with the protection, preservation, perpetuation and judicious control of populations of rare species of plants (or) animals in their natural habitat.

The conservation of wild life is required for the following benefits:

a. Balance of nature

b. Genetic resource

c. Research activities
d. Economic value
e. Recreation
f. Tourism
g. Education

Some plants and animals have already become extinct and there are many species facing danger of extinction.

The reasons for depletion are:

1. Absence of cover (or) shelter
2. Destruction of natural habitats due to deforestation for cultivation, construction of roads, railway routes, dam construction reduction in the area for free movement of wild animals which retard the reproductive capacity of certain wild animals like deer, bison, rhinocerous, tiger etc.
3. Destruction of wild plants of forests for timber, charcoal and firewood. This would often deprive wild animals of their most palatable foods and ultimately affects their survival
4. Overgrazing by domestic animals that convert that area into desert
5. Poaching for many purposes (i.e.) for food, skin for ivory, rhino horns etc. Noise pollution by various transporting media (trucks, buses, rails, aeroplanes etc) also causes great destruction of wild life
6. Natural calamities such as flood, drought etc have also caused great destruction of wild life
7. Export of some species have adversely affected the wild life.

The botanical Survey of India (BSI) could so far complete survey of plant resources. Data regarding all endangered plant species of the country are also not yet complete.

In India, nearly 450 plant species have been identified as endangered. A list of some species in different parts of the country is given below:

Himalayas and Western India

1. *Rauwolfia serpentia (Pinaceae)*
2. *Delphinium pauciflorum (Meliaceae)*
3. *Diplomeris hirsuta (oleaceae)*
4. *Atropa acuminata (Solanaceae)*
5. *Balanophora dioica (Balanoporaceae*)

Other important plants of endangered species

1. *Nepenthes khasiana (pitcher plant)*
2. *Drosera*
3. *Eraeminus*
4. *Rhododendrons*
5. *Dioscorea deltoidea*

Peninsular India

1. *Eleocarpus recurvatus*
2. *Asparagus fysonil*
3. *Gnetum ula (Gnetaceae)*
4. *Piper barberi (Piperaceae)*
5. *Santalum album (Santalaceae*)

About 28 species out of 36 carnivores are endangered. These include mainly Indian jackal, red fox, Indian fox, wild dog, Himalayan brown jackal, leopard, desert cat, jungle cat etc.

Besides great Indian one-horned rhinoceros, smaller one-horned Indian wild ass, Tibetan wild ass are also endangered.

About 12 out of 19 primates are endangered.

Andaman wild pig, swamp deer, Alpine musk deer, forest musk deer, black buck (or) Indian antelope, Indian bison, wild buffalo are also listed under endangered species.

Wildlife management of India has taken steps to protect and preserve the endangered (both flora and fauna) species.

Both Government and the individuals should take proper actions and steps in protecting and preserving the endangered species.

3. Ethnobotanical importance of tribal medicine

Study of ethnobiology gives great importance in developing our knowledge about the plants grown and used by ethnic or tribal communities. The term “ethnobotany” was first given by Harchberger (1885). Dr. S. K. Jain is known as “Father of Indian Ethnobotany”. He only made several pioneering investigations. Ethnobotany has now become significant and a new dimensions has arised. Modern civilization came to know the importance of plant products used by us today either as food or as a medicine. These are the gift of those early men who used those to satisfy their hunger and heal their wounds. Ethnobiological study today is towards the understanding and bioprospecting of biodiversity which have much influence on economic, ecological, social and political

signifinance on the modern civilization. Ethnobotanical survey has helped in locating and conserving the threatned and the endangered plant species. India is a country with large ethinic and biological diversity from the temperate of Himalayas in the north to the Nilgiri's and the tropical rainforest of western ghats in south form the wet rain forest of the east to the dry Thar desert in the west. There are several reports about the tribals of Assam and Arunachal Pradesh who have used the indigenous medicinal plants for the treatment of insanity, jaundice, cancer, rabies, snake bite, bone fracture etc.

1. Ethnobotanical medicine used in Himachal Pradesh and Uttar Pradesh.: **(RRL)** The **R**egional **R**esearch **L**aboratory, Field Research laboratory are taking steps to conserve the wild medicinal plants. Some important wild plants species are:

1. ***Agrimonia eupatoria***
Flowers used to treat liver enlargement and also used as blood purifier.

2. ***Adhatoda zealanica***
Leaves, flowers and wood ash used in cough, cold, asthma and tuberculosis.

3. ***Artemisia maritime***
Foliage is used to eradicate tapeworms and roundworms in children

4. ***Valeriana wallichii***
Extracts of roots are used as "nervine tonic" and dried root powder as antispasmodic in children.

5. ***Atropa acuminata*:**
Root paste is used in asthma and whooping cough.

6. ***Rheum emodi***
Powdered root used with mustard oil for joint pains

7. ***Asparagus adscendens***
Root bark used as wonderful tonic.

8. ***Asparagus racemosus***
Roots used in stomach complaints and also in dysuria.

9. ***Glycyrrhiza glabra***
Stem and roots used in respiratory problems.

10. ***Centella asiatica***
Leaves are wonderful brain tonic. Fresh leaf juice used to treat cataract.

11. ***Rubia cordifolia***

Roots are used in joint pains and as blood purifier.

12. ***Azadirachta indica***

Leaf decoction and infusion of bark and fruits given in fever.

13. ***Selaginella bryopteris***

Whole plant used to restore vitality and agility in body

14. ***Boerharia diffusa***

Root is used in rheumatism and eye complaints

15. ***Acorus calamus***

Powder of rhizome is used for removing lice and also as analgesic in headache.

2. Ethnobotanical medicinal plants of North east India (Assam, Meghalaya, Arunachala Pradesh, Manipur, Mizoram, Nagaland and Tripura).

1. ***Rubia Cordifolia***

Root decoction given to women in gynaecological disorders.

2. ***Artemisia nilagirica***

Leaves are used for scabies.

3. ***Alpinia galanga***

Rhizome is used in Jaundice. It increases digestion power and sexual potency.

4. ***Solanum surattense***

Leaf infusion is used in severe cough and asthma.

5. ***Justicia adhatoda***

It is used for curing cough and respiratory problems.

6. ***Cucurbita moschata***

To stop bleeding and in severe cough and fever.

7. ***Cannabis sativa***

Leaves are used for cancerous growth in stomach.

8. ***Calotropis procera***

Latex and flower buds used in stomach aches and body pain.

9. ***Cissampelos pareira***

Roots are used in skin diseases.

3. Ethnobotanical medicinal plants of central India: (Madhya Pradesh, West Bengal, Bihar).

10. *Eclipta prostata*

Powder boiled in water is given for Malaria. Ash mixed with coconut oil used in conjunctivitis.

11. *Rauwolfia serpentina*

Roots along with petiole of betel leaf were made into paste and given to cure facial paralysis.

12. O*cimum americanum*

Seeds soaked overnight in water to check diarrhoea.

13. *Murraya Konigii*

Tea made of leaves is given to check dysentery.

14. *Amaranthus spinosus*

Fresh leaves cooked when taken expels kidney stone through urine.

15. *Carica pappaya*

Root powder (6g) mixed with 100 ml of water 3 spoons given twice daily to dissolve kidney stones.

16. *Raphanus sativus*

Root juice mixed with alum and boiled in iron pot given for piles.

17. *Cajanus cajan*

Leaf juice with black pepper and butter milk given for jaundice.

18. *Zingiber officinale*

Rhizome powder along with turmeric powder, jaggery and lime made into pills taken for 20 days for tuberculosis.

19. *Bryophyllum pinnatum*

One leaf with 2 black pepper taken twice a day dissolves kidney stones.

4. Ethnobotanical medicinal plants of south India: (Orissa, Andhra Pradesh, Tamil Nadu and Andaman and Nicobar Islands) These states have large tribal population belonging to several ethnic groups.

20. *Aloe vera*

Leaf juice mixed with ginger juice is used to cure acute indigestion and jaundice.

21. *Ficus bengalensis*

Prop roots mixed with curd taken for enhancing the memory..

22. *Bauhnia purpurea*

Fresh bark and roots with *Asparagus racemosus* mixed with cow milk given for reducing the stones in gall bladder.

23. ***Centella asiatica***

Leaf paste rubbed on the palm and foot, facilitate easy delivery.

24. ***Cucurbita maxima***

Seed kernels along with honey will cure insanity.

25. ***Ricinus communis***

Seed kernels take once a week relieves constipation.

26. ***Euphorbia tirucalli***

Few drops of latex along with water is a purgative for constipation.

27. ***Nerium indicum***

Floral buds with that of *Hibiscus rosasinensis* is boiled and vapour exposed to affected part to cure leprosy.

28. ***Hibiscus rosasinesis***

Leaf paste applied on the forehead in severe headache.

29. ***Terminalia arjuna***

Bark decoction along with cow milk relief chest pain and heart palpitation.

5. Ethno botanical medicinal plants of Andhra Pradesh:

30. ***Cyanotis tuberosa***

Root paste is used in chronic wounds.

31. ***Phyllanthus reticulatus***

Leaf is used to cure bone fracture.

32. ***Solanum nigrum***

Leaf juice is given in jaundice.

33. ***Tylophora indica***

Leaves powdered with black pepper and garlic made into pills which isgiven for 11 days for treating rabies.

34. ***Canthium parviflorum***

Leaf juice given for fever 2. Root juice is used as anathematic.

35. ***Cyanotics tuberosa***

Roots paste is used in the treatment of chronic wounds.

36. ***Triumfetta pentandra***

Dried leaf powder given for curing diabetes.

37. ***Argemone mexicana***

Plant paste is applied on the white patches on lips and body

38. ***Pergularia daemia***

Root powder along with curd is given to women for fertility.

6. Ethnobotanical medicinal plant of Tamilnadu and Karnataka:

39. ***Mirabilis jalapa***

Rhizome decoction is used in piles.

40. ***Solanum nigrum***

Leaves with palm jaggery ground with lemon juice and water is given to induce fertility in woman.

41. ***Colacassia esculenta***

Boiled leaves and patrols is given with rice to treat kidney stones.

42. ***Tephrosia purpurea***

Roots are used as anti-fertility agent to prevent conception.

43. ***Acalypha indica***

Leaves with onion extract is poured into nose and ears and rubbed on neck and chest in the case of epilepsy.

44. ***Ipomoea obscura***

Leaf ground with onion and the extract given for cataract.

45. ***Centella asiatica***

Plant paste given for jaundice.

46. ***Phyllanthus rheedii***

Leaves are fried and given for jaundice.

47. ***Anisomeles indica***

Root, leaves and inflorescence are given for malaria.

48. ***Hydrocotyla javanica***

Plants ground with raw turmeric is given in jaundice.

49. ***Leucas aspera***

Leaf extract is given for stomach disorders.

50. ***Euphorbia hirta***

Plants eaten raw in dysentery.

51. ***Sida cordata***

Plant juice given to control diarrhoea.

52. *Bauhenia racemosa*

Stem bark and fruits powdered given with goat milk in dysentery

53. *Boerhaavia diffussa*

Roots are chewed to cure acidity and flatulence.

7. Ethnobotanical medicinal plants of Kerala :

54. *Eclipta alba*

Whole plant used in treating asthma.

55. *Calotropis gigantea*

Latex and stem bark used in toothache and for snakebite.

56. *Cephalandra indica*

Root used for mental disorders.

57. *Phyllanthus niruri*

Whole plant used as very good remedy for cure of jaundice.

58. *Datura metel*

Leaves, flowers and seeds are used in asthma.

59. *Argemone mexicana*

Seeds, leaf and stem peels are used in eczema and fracture.

60. *Trichopus zeylanicus*

Tender leaves are used in several ailments.

61. *Solanum surattense*

Fruits and seeds given for stomach ailments, fever and tooth ache.

62. *Centella asiatica*

Leaves are used as brain tonic and given for skin diseases and leprosy.

63. *Phyllanthus amarus*:

leaves and roots are used in jaundice.

8. Ethnobotanical medicinal plants of Western India: (Maharashtra, Gujarat and Rajasthan)

(A) Maharashtra

64. *Rauwolfia serpentina*

Roots are used for controlling blood pressure

65. *Terminalia arjuna*

Bark leaves are used in wounds.

66. ***Centella asiatica***
Whole plant is used in tuberculosis.

67. ***Piper nigrum***
Leaves, roots and fruits are used in rheumatic pains.

68. ***Albizza lebbeck***
Roots and seeds are used in diabetes.

69. ***Azadirachta indica***
Young leaves, fruits and seeds are used in tuberculosis.

70. ***Aristolochia indica***
Root paste is used in leucoderma.

71. ***Acacia catechu***
Bark and heart wood is used in chest pain.

72. ***Wrightia tinctoria***
Bark and seeds are used in jaundice and to protect live.

73. ***Tridax procumbens***
Leaf juice is useful in removing kidney stones.

74. ***Launaea sermentosa***
Leaves are used to dissolve kidney stones.

(B) Rajasthan and Gujarat

1. ***Solanum surattense***
   Dried roots are given for cough, bronchitis, asthma, chest and muscular pain.

2. ***Calotropis procera***
   Leaf, flower and milky latex used in several ailments.

3. ***Withania somnifera***
   Root is rejuventor, restorative and for combating several human ailments.

4. ***Tephrosia purpurea***
   Used in leucoderma and to improve liver function.

5. ***Tribulus terrestris***
   Fruits are used in urinary and kidney problems.

6. ***Ziziphus nummularia***
   Leaves are used in asthma and flowers in eye diseases

7. ***Aloe vera***
   It is used for skin burns and healing wounds.

8. ***Boswellia serrata***
   Bark of the tree is used in arthritis and back pains.

9. ***Sida rhombifolia***
   Leaves and roots are used in rheumatic pains nervous and urinary disorders.

10. ***Euphorbia hirta***
    The milky latex has beneficial effects on heart and respiratory organs.

11. ***Tinospora cordifolia***
    Root bark is used in fever.

12. ***Acalypha indica***
    Useful in asthma, pneumonia, bronchitis, rheumatism and also as laxative.

13. ***Centella asiatica***
    It is used as sedative and mental tonic.

14. ***Fumaria indica***
    Dried powder of whole plant is used to remove kidney stones.

15. ***Cassia tora***
    Leaves are used in stomach problems and seeds are used in the treatment of leprosy.

16. ***Sida rhombifolia***
    Leaves and roots are given in rheumatic pains in nervous and urinary disorders.

Ethnic societies throughout India, use their respective systems of medicines. Locally available herbs are used by them, their uses, concepts, treatment of diseases pharmacology are different for different ethnic groups. Every tribals are specialized for particular ailments and diseases. They have the knowledge about the herbs and their relation to cure the diseases. Thus tribal or ethnic societies play a key role in development of modern medicines and some of the herbal plants cultivated by them are conserved and preserved.

4. Food crops of tribals

Many rare and primitive cultivars of cereals, pseudo cereals, millets, pulses and vegetable have almost disappeared in the modern society, but they are still in practice by

the primitive tribal communities. The tribals derive very basic needs for their survival from biodiversity. Leaves, fruits, nuts, tubers etc are used as food. They use wide range of biodiversity products, fuel for cooking, fodder for their livestock, fibers for clothing, timber, rope bark, bamboo and medicinal herbs for health care etc. They also protect and preserve the forest biome and conserve its biodiversity. Several tribal societies of India use traditional farming and grow traditional crop plants and their wild relatives. These plants are more resistant to pest and fungal attack and more resistant to drought. They have high food value (proteins). Many varieties of crop plants are used by the tribals of India; Some prominent examples are rice, millets, leafy vegetables, fruits pseudo cereals etc.

Rice (*Oryza sativa*)

Many varieties of rice are grown in the north eastern and peninsular regions of India. In these area 6000 different types of rice are grown by 100 ethnic groups. They cultivate 26 primitive varieties of rice possessing white and red kernel. Rice varieties resistant to insects are

1. resistant to gall midge. Pattambi (PTB) 10, PTB 12, 18, 21, PT 27, PTB 28, PTB 32, valsara, champara.
2. resistant to stem borer: pattambi 15, PTB 18, PTB2.
3. resistant to green leaf hopper: Pattambi 18, PTB 21, 24 and PTB 27.
4. resistant to Brown plant hopper: pattambi 19, PTB 20, 21
5. resistant to white backed plant hopper: pattambi 33.

Rice varieties resistant to diseases:

a)	resistant to rice tangro virus	:	pattambi 18, chennella, valsara, champara, vellathil cheera
b)	Resistant to rice blast	:	Pattambi 10, PTB 18, PTB 19, PTB 20, 21 and 32.
c)	Resistant to bacterial leaf blight:		Pattambi 20.

Rice varieties tolerant to salt stress are Pokkali, Cheruviruppu. Several genetically unique forms of wild rice species were preserved and also maintained. This genetic base of rice conserved by the tribals of India has given an insurance against pest and diseases.

Maize is an important crop of northeast India. There are different varieties of maize used.

The ethnic societies in the central and peninsular India cultivated large amount of pearl millet (*Pennisetum typhoides*) finger millet (*Eleusine coracana)*, little millet (*Panicum sumatrense*). Along with finger millet Pseudo cereals such as buck wheat (*Fagopyrum esculentum*) and amaranth (*Amaranthus polygamus*) were grown by the Himalayas traditional farmers.These crops are used for dual purposes for food and fooder or as leafy vegetables.

Some important leguminous plants were cultivated by the tribals are species like Canavalia, Vigna, Mucuna used in day to day life activities. Soya bean have high fat contents and oils are extracted from them, used for cooking wild legumes like Atylosid are the progenitors of *Cajanus cajan*. Tribals of Peninsular India grow black gram (*Phaseolus mungo*), green gram (*Vigna mango*) horse gram (*Dolichos biflorus*) chick pea (*Cicer arietinum*) lablab bean (*Dolichos lablab*) Jack bean (*Mucuna utilis)*. Tribals of western north eastern and Himalayas have rich genetic diversity. Some examples are (*Phaseolus vulgaris*) rice bean (*Vigna umbellata*) and black gram (*Phaseolus mungo*). Legumes are rich source of protein and used as both as fodder for animals and also as food.

Many species and varieties of fruits, vegetable crops like banana, mango, orange, pineapple and jack fruit, radish, brinjal, bottle guard, bitter gourd etc are being grown by the tribals. Wild variety of organs was identified in Assam. Pineapple in Meghalaya are of two types.

1. the large green variety with plenty of juice
2. smaller one with yellow skin and more sweeter. Thus the tribals of India, have used various food crops and these plants are now used as a food source by the Modern Society.

5. Wild edibles of tribals

The ethnic or tribal people mostly live in and around the forest. They have come across various types of edible plants during their visit: They have cultivated these crops which have high nutritious and high amount of energy content. They were healthy due to the consumption of wild edible plants. Some of them are consumed raw and some as cooked food. Most of these plants are disease resistant. There are 3,900 or more wild plant species used as food by the tribals of India and about 800 species are new claims. Nutritional evaluation of some 200 wild edible plants used by the tribes gave promising results.

Wild species consumed as source of food are

1.	Wild fruits as food	:	Premna tomentosa, Carissa carandas, Memecylon edule.
2.	Wild seeds as food	:	Cycas circinalis, Dolichos trilobu, Entada puresatha and Xylia Xylocarpa.
3.	Wild leaves as food	:	Hibiscus furcatus, Mimosa intsia,Cassia tora
4.	Wild tubers	:	Dioscorea alata, Dioscorea bulbifera, Dioscorea oppostifolia and Dioscorea pentaphylla
5.	Wild corns as food	:	Colocasia esculenta
6.	Wild Rhizomes as food	:	Canna indica.

Wild plants used as food are Amaranthus spp, Canthium dicoccum, Lycianthes laevis, Ficus racemosa, Trichosanthes nervifolia, Dioscorea sp. are edible tuber plants.

Wild edible plants for the ethnic people of Kerala. There are 35 different tribal varieties in Kerala. They use a wide variety of wild edible nuts, fruits, vegetables, cereals and pulses. They use about 150 species of wild edible plant. Some of them are listed below:

Wild edible plants	Ethnic people using	Parts used
1. Cassia tora	Kadar tribe	Leaves
2. Dioscorea spp.	Kani, Irular and mudugar	Root tubers
3. Trichopus zeylanicus	Kani tribe	Tender leaves
4. Ixora coccinea	Irular and malapandram	Ripe fruits
5.Opuntia vulgaris	Kani, kurumbar tribes	Fruits
6 Bambusa arundinaceae	Paniyan tribes	Seed powder after cooking
7. Solanum surattense	Kadar and Muthuran tribe	Unripe fruits
8. Cycas circinalis	Malapandram and kani tribes	Powdered seed after boiling
9. Polygonum Chinense	Kadar and Muthuran, Mudugar tribe	Leaves and ripe fruits unripe fruits
10. Canavalia gladiata	Kani tribe	Ripe fruits
11.Utleria salicifolia	Irular and Muthuran tribe	Root tubers
12.Sterculia villosa	Krumba and karuman tribes	Seeds
13.Mucuna pruriens	Kani and kadar tribes	Seeds
14.Arenga wighti	Kani and cholanaicken tribes	Tender inflorescence
15.Cleome gynandra	Irular tribe	Leaves cooked

In Manipur, 29 ethnic communities use wide variety of wild plants. About 400 species ranging form algae to angiosperms are used as food. Mostly meitiei and pongmei tribes inhabit in these hilly areas

Sl. No.	Wild edible plant	Plant parts used
1	*Ipomoea alba*	Leaves and calyx
2	*Cassia tora*	Seeds
3	*Dioscorea spp.*	Root tuber
4	*Ficas religiosa*	Fruit
5	*Oryza rufipogon (wild rice)*	Grains
6	*Solanum surattense*	Fruits
7	*Oxalis corniculata*	Leaves
8	*Sterculia villosa*	Seeds
9	*Vallisneria spiralis*	Young leaves
10	*Alocasia indica*	Petiole
11	*Gylcine max*	Seeds
12	*Euphorbia hirta*	Leaves
13	*Fagopyrum cymosum*	Leaves
14	*Ficus bengalensis*	Fruits
15	*Phyllanthus acidus*	Leaves and fruits
16	*Vallisneria spiralis*	Young leaves
17	*Centella asiatica*	Seeds
18	*Amaranathus spinosus*	Young shoots

Assam state is inhabited by number of hilly tribes of several ethnic groups. Prominent among them are garo, mikir, Abor, Angani and Khasi. Some of the important wild plants used as food are listed below.

Sl. No.	Wild edible plant	Plant part used
1	*Albium tuberosum*	Whole plant
2	*Ipomoea aquatica*	Leaf and shoot
3	*Justicia adhatoda*	Flower
4	*Solanum indicum*	Fruit
5	*Solanum torvum*	Fruit
6	*Solanum nigrum*	Leaf and shoot

7	*Stellaria media*	Leaf and shoot
8	*Bauhinia purpurea*	Leaf and flower
9	*Calamus erectus*	Shoot and fruit
10	*Dioscorea sp.*	Tubers
11	*Oxalis corniculata*	Whole plant
12	*Alpinia galanga*	Inflorescence
13	*Begonia palmata*	Leaf
14	*Hydrocotyl javanica*	Whole plant
15	*Eichhornia crassipes*	Shoot, leaf and flower
16	*Vallisneria spiralis*	Young leaves
17	*Centella asiatica*	Seeds
18	*Amaranathus spinous*	Young shoots

Different ethnic people living in Himalayas inhabited this area. They are Gujjars, gaddies, lodhs, Majhis, Gonds and nuts. Some of wild edible plants used by them are listed below:

Sl. No	Wild edible plant	Plant part used
1	*Amaranthus spinosus*	Tender shoot leaves and grains
2	*Cassia tora*	Tender leaves and pods
3	*Ficus palmata*	Figs and leaves
4	*Physalis minima*	Ripe fruits
5	*Murraya koenigii*	Leaves and fruits
6	*Cordia dichotoma*	Fruits
7	*Dioscorea spp.*	Tubers
8	*Amaranthus viridis*	Tender shoots, leaves and grains
9	*Berberis aristrata*	Ripe fruits
10	*Bauhinia variegata*	Flower buds

The important tribes of Arunachala Pradesh are Apatanis, Adis, Akas, Bangims, Mijis, Thangas, Khambas and Tangins. Nature has endowed Arunachala Pradesh with diverse flora and fauna. It is considered as the “Cradle of Flowering plants”. About 5000 species, ranging from trees, tree ferns, orchids and Rhododendrons are present. The tribes practice “Shifting cultivation”. They harvest double crops system, cultivate paddy cum

pisciculture (Fish and paddy). Some of the important wild plant species used by them as a source of food are listed below:

Sl. No.	Wild edible plant	Plant part used
1	*Solanum indicum*	Leaves and fruits
2	*Cyperus diffusus*	Roots
3	*Bambusa tulda*	Young shots
4	*Gnetum gnemon*	Seed
5	*Albizzia julibrissin*	Leaves as tea
6	*Coffea khasiana*	Seeds substitute
7	*Centella asiatica*	Young parts
8	*Dioscoria spp.*	Tubers and bulbils
9	*Sterculia hamiltonii*	Seeds
10	*Alocasia indica*	Rhizomes

The Ethnic people of Nagaland are Mongoloid, Angamis, Zeliangs, Rengmas, Chakesang, Pachuris, lothas, Konyaks, chang sema etc. The wild species used by them as food are listed below:

Sl. No	Wild edible plant	Plant part used
1	*Allium bakeri*	Underground parts
2	*Alpinia bracteata*	Young inflorescence
3	*Bauhinia purpurea*	Flowers and young inflorescence
4	*Solanum indicum*	Fruit
5	*Baccau ramiflora*	Fruits
6	*Manihot esculenta*	Tubers
7	*Ficus cunia*	Inner bark of stem
8	*Zanthoxylum aceanthopodium*	Fruits and seeds

The ethnic people of Tamil Nadu inhabit the Nilgiri and Palani Hills of Tamil Nadu. These areas are rich in biodiversity. Most prominent tribes are Gounder, Mala wali, Kota, Toda, Chenchum, Badaga and Veduvan etc. They use varieties of wild species as food sources. Some of the important ones are listed below:

Sl. No.	Wild edible plant	Plant part used
1	*Habenaria sp.*	Rhizome
2	*Pergularia sp.*	Root
3	*Securinega sp.*	Whole plant
4	*Brachystelma sp.*	Whole plant
5	*Mussaenda sp.*	Whole plant
6	*Nothopegio sp.*	Whole plant

The ethnic people of Madhya Pradesh are marin, muria, gond,Halba, Kanjur, Kondas, Basor, Bheels and Sahariyas etc. This region is thickly forested and the tribals depend largely on the forest for their lung. Some of the important wild species are listed below:

Sl. No.	Wild edible plant	Plant part used
1	*Amorphophallus paenoiifloium*	Petiole
2	*Bauhinia purpurea*	Leaves
3	*Bauhinia vahlii*	Tender pods and seeds
4	*Ficus virens*	Tender leaves
5	*Oryza rufipogan* (wild rice)	Grains
6	*Shorea robusta*	Seeds and fruits
7	*Xylia xylocarpa*	Roasted seeds
8	*Ficus virens*	Tender leaves
9	*Diopyros melanoxylon*	Fruits
10	*Physalis minima*	Fruits
11	*Ipomoea aquatica*	Leaves and shoots
12	*Mucuna pruriens*	Young shoots, leaves and seeds
13	*Amaranthus spp.*	Leaves and shoots
14	*Grewia hirusta*	Fruits
15	*Sterculia urens*	Seeds

Orissa is inhabited by large number of tribal population belonging to various ethnic group popular among them are Toto, Birhor, Oraan, Saora, Munda, Birja, Santhals and Khonds. Some of the edible wild plants used by them are listed below:

Sl. No.	Wild edible plant	Plant part used
1	*Bauhinia purpurea*	Tender leaves
2	*Dioscorea bulbifera*	Tubers
3	*Licuala peltata*	Pith of basal stem
4	*Solanum surattense*	Seeds
5	*Artocarpus lakoocha*	Fruit pulp
6	*Cansjera rheedii*	Leaves
7	*Ipomoea hederifolia*	Raw tubers
8	*Oroxylon indicum*	Bark
9	*Clematis roylei*	Leaves
10	*Andrographis paniculata*	Leaf and shoot

Andhra Pradesh inhabitats large number of tribal population in the Eastern Ghats. Chenchus, sugalis and Yerukalas are prominent among them. Important edible plants are listed below:

Sl. No.	Wild edible plant	Plant part used
1	*Pueraria tuberosa*	Root
2	*Mimosa prainiana*	Root powder
3	*Cyanotis tuberosa*	Root tubers
4	*Curculigo orchioides*	Root
5	*Hybanthus enneaspermus*	Whole plant
6	*Boerhavia chinensis*	Root powder
7	*Dioscorea oppositifolia*	Tubers

The ethnic tribes use many varieties of wild plants and plant products as their food source. Some of them even use the non-conventional food crops like pseudo cereals; even though they use these food items, they appear healthy and hale. The wild roots, tubers, fruits, berries, flowers, seeds, leaves, stem etc have very high nutritional value. Investigations on the nutritional value of these wild crops shows high energetic value and protein content. Several wild food plants are also of medicinal values. This is the main reason the tribal people are healthy and leading a disease free life.

6. Wild relatives of petro crops

Petrol and diesel are predominantly derived from the plant sources. There are different varieties of plants which yield petrol-like substances and in some plants whose seeds and fruits can be employed for extracting diesel. In the event of petrol scarcity, petrol can be replaced by vegetable oil.

Vegetable oil don't pollute the environment but crude oil while purification and separation emits toxic gases. Cultivation of petro plants, extraction of oils from the seeds are simple processes when compared to crude oil. The oil crisis during the world war II had led to the search of alternate products (i.e) petro crops. Mainly the petroleum is extracted from the plants belonging to the families *Euphorbia*, *Asclepidaceae* and *Apocynaceae*.

Euphorbia abyssinica was used in the gasoline refinery. Plants which are rich in hydrocarbons yield petroleum products.

Some examples:

1. *Euphorbia lathyris*- (gophar plant)
2. *Euphorbia tirucalli* (milk bush)
3. *Calotropis procera* – (milk weed)
4. *Copaifera landsdorfii*
5. *C. multijuga*
6. *Pittosproum resiniferum* (petroleum nut) *P. resiniforum* bears fruits rich in hydrocarbon compounds. Oil extracted from these fruits smells like petroleum. *C. landidorfii* and *C. multijuga* yield about 20 – 30 litres of oil in 2-3 hours in a single tapping. The Euphorbia plants are uprooted, dried, extracted with chemical solvents and it is subjected to catalytic conversion to obtain petroleum products. (i.e) gasoline, heating oil, gases and other products. Cactus like species, *Euphorbia nerrifolia* and *E. caducifolia* can be used for extracting the latex, which on coagulation can be directly subjected to hydro-cracking without any pretreatment.

The advantages are

1. Euphorbia plants are mostly xerophytes plants grow in wild and semi arid lands.

2. They do not require irrigation and fertilizers for growth.
3. Jatropha: Jatropha oil is used as a lubricant for bullock cart axes and other agricultural implements. A single hectare of Jatropha plantation can produce one quintal of seeds. In the 2nd year it increases to 75 quintals. After 10 years in rain fed areas, 125 quintals are produced in rain fed areas. The cost of the seed is Rs. 350/= per quintal. Cash returns are to the tune of 17,000 to Rs.31,000 per hectare. India imports Rs.4,000 million worth of Jatropha oil for every year for industrial use.
4. The Jatropa is efficient and environmentally clean substitute for diesel.
5. Engine parts are in good condition after running them with Jatropha oil for 1,000 hours.
6. The oil of petroleum nut (*Pitosporum resiniferum*) contains monterbene, hydrocarbons and pinene 38 percent and myrcene 40%. Hilly people use this fruits for igniting the light. Fruits of *Pittosporum resinifarum* are fitted in bamboo tubes and ignited which serves as a torch light.
7. The algae *Botryococcus braunnii* is a colonial green algae which has rich source of hydrocarbons closely resembles the crude oil. It occurs in the lake of Australia, Russia and United Kingdom.

UNIT III Non timber forest products, spices & conservation, cosmetics, marine products, antifouling and anti corrosive protected compounds and other pharmaceutical products – Sport fisheries and recreation.

Non timber products

Forests yield a number of products, which are beneficial to mankind. The forest products have been classified under two heading

1. Major products-Timber, pulp, and matchwood, round wood, firewood, charcoal, wood etc. form the major products.
2. Minor products - Comprises of bamboos canes, fodder, grass, gum, resins, lac, drugs and spices, tan stuff, dyestuff, seeds, tender leaves, honey etc.

Forests play a very important role in the life and economy of a country. Forest vegetation and its soil organisms form 90 percent of the total biomass on the land. The tribals of India depend on the minor forest produce for their survival and livelihood. They are mahua flowers, sal seeds, sal and tender leaves, fruits, resins, lac, bamboo etc. Around 80 percent of the forest dwellers collect as high as 50 percent of the food from the forests.

Fodder

Cereal grains are made into flour, used as a meal at home. Crops such as Soya, groundnut and rape are used for the extraction of edible oil and these residues are supplied to the cattle. Forests have great economic importance besides their role of

sustaining ecological balance and protecting environment. In addition to firewood and timber, forests provide a number of other products known as minor forest products, which are widely used in domestic field and industries. They include fibers essential oils, oil seeds, tans, dye, gums, resins, oleo gum resins, drugs, spices, insecticides, leaves edible products etc.

Food products

New plant foods that are rich in protein are identified. Proteins and other substances are synthesized by the plants. Leafy forages are the crop that gives the greatest yield. Proteins and other substances are synthesized in leaf. Leafy vegetables like *Brassica oleracea* yields 0.5 tonnes/ha of edible protein in 6 months. They contain vitamin A. Protein rich plants (leaf protein) are eaten as raw (eg. Oats). These plants promote digestion and prevent the occurrence of digestive disorders. Protein content in the leaves is pressed out. The protein is then coagulated, filtered off and the edible mass is incorporated in various foodstuffs. The percentage of protein extracted depends on the species used and the age and protein content of the leaf. Sugar beet yields 800 kg/ha of protein.

Stems and other similar parts are seldom used as food by people.

1. *Sagar metroxylon*: It is a rich source of starch
2. *Saccharum officinarum*: It is rich source of sucrose
3. *Solanum tuberosum*: It stores starch in its tuber

Following plants are being cultivated for their tubers.

1. Cassava (*Manihot esculenta*)
2. Potatoes (*Solanum tuberosum*)
3. Sweet potatoes (*Ipomoea batatus*)
4. Yams (*Dioscorea*). Dependence on cassava and yams is responsible for protein deficiency.

Flowers of certain plants in their various stages of development are used as flavouring agent. Cauli flower is a useful vegetable having 25-30 percent of protein. The pods and immature seeds of various varieties of Phaseolus contain high protein and digestible carbohydrates. Soya bean has a high protein content. Immature reproductive parts of plants also contain high amount of nutrition.

Fresh vegetables like beans, leaves and coconuts are extensively used. Such foods are energy yielding foods rather than protein sources.

Seeds

Mature seeds can be stored for a long time. Seed store high amount fatty acid, oils, protein. These seeds are used as food source.

Around 10-12 percent protein content of the diet is supplied through cereal seeds. They supply high proportion of energy. *Triticum sativum*, *Zea mays*, *Avena sativa* have high protein content. These are used for making foods such as bread, chapattis and pasta. Rice *Oryza sativa* has less amount of protein. It can be separated from the main body of the endosperm by continued abrasion and other mechanical device. Around 21 percent of protein can be separated out from rice bran which, are rich in thiamine and riboflavin. These products are mixed as an ingredient in baby foods. Likewise wheat flour is separated into protein rich and protein depleted fractions. This is used in traditional Chinese food for making gluten. Protein enriched wheat flour is used regularly for making starch reduced bread.

Legumes have very high amount of protein compared to cereal seeds.

1. Field bean (*Vicia faba*) contains 25 percent of protein and is more prolific than the broad bean, a large seeded variety. It is considered as a source of isolated protein for use in human food.

2. Ground nut (*Arachis hypogea*) has 50 percent protein content. It is used as supplement in infant feeding. These are traditional foods in many parts of the world. Certain legume seeds eg. Lathyrus odoratus contain more delicious compounds. They produce toxic compounds such as trypsin, inhibitors, haemoglutinins which are destroyed by cooking. In soya bean also trypsin inhibitors are present but it has a little effect on humans. Soya was made edible by of fermentation and by extracting much of the protein and coagulating it with gypsum. When cooked they used to develop a sort of bitterness due to ethyl vinyl ketone. The undesired nature can be prevented by toasting the beans.

Cotton seeds *Gossypium hirsutum* is used as a cattle fodder. It has a good nutritional value. Cotton seed contains 50-60 percent of protein.

Many other seeds are being used as sources of oil and protein

1. Sunflower (*Helianthus annuus*) is one of the richest source of edible oil.
2. Saf flower (*Carthamus tinctorius*) oil is highly prized because of the presence of unsaturated fatty acids.
3. Castor (*Ricinus communis*) is an important lubricant
4. Cow pea (*Vigna unguiculata*)
5. Winged bean (*Psophocarpus palustris*) are used in Africa and south east Asia. a) Seeds of fat hen are eaten in Europe. *Chenopodium album* is eaten in Mexico. Seeds and other reproductive parts of various plants have varied role in human nutrition.

Fruits are important sources of ascorbic acid. They supply less amount of protein and high amount of energy e.g. Bananas. Plantains are important source of energy.

Coconut (*Cocos nucifera*) is an important protein yielding tree. It has protein with high good nutritive value. Oil is extracted from Copra.

New crop plants are being used traditionally for food and fodder. Agave is an unconventional food yielding tree from which pluque is made. The juice from contains mixed sugar. It is a probable source for crystalline sucrose.

Production of natural rubber has increased from 15,830 tones to 5.22 lakh tones in 1995-96. Kerala is the major rubber producing state and Tamil Nadu accounts for 86 percent of the total area.

India produces a number of horticulture plants (crops) including fruits, vegetables, flowers, spices and plantation crops. Plantation agriculture is an important land use activity in many parts of the country. Traditional agro forestry system include growing multipurpose trees, palms, rubber, vegetables, fodder, fuel wood and timber.

Bambusa Eucalyptus, Casurina etc are products of the forest. Many hand made articles are made from this.

Forestry is an integrated operation farming, animal husbandry and horticulture. The domestic animals give milk, meat and provide butter, cheese, eggs and other useful goods. Other secondary outputs of the animals include hides and skins, wool, honey, gums and wax.

Sewan is an extremely nutritious grass, which grows in clumps. It can grow fast even with little rainfall. Jharbai and Khejdii provide excellent fodder during the dry months when no fodder is available. When the rains are inadequate and crops wither off, the farmers are still assured fodder from these. “Social fencing” resulting in regeneration of grasses in the hills. This provides increased fodder and fibre grasses to the villagers. Ivory, rhino horns, furs, skins, musk, peacock feathers are the other products from the forest.

Silk is a product from forest. Silk worms *Bombyx mori*, Tasar, Eri are the different varieties of silk worm . The culture of the above is referred as sericulture. Silk threads are taken by immersing the pupae in hot water. After the processing is carried out. The silk threads are brought out from which beautiful silk sarees are made.

Bee keeping is a profitable venture. Bees collect nectar and pollen grain from plants. Nectar a sweet secretion from the floral and extra floral nectarines of flowers is the raw material for honey. Pollen is a protein rich food for the bees. The plant that yield these materials are known as Bee pasturage.

Plants visited by bees are as follows:

1. *Tamarindus indica* (tamarind)
2. *Azadirachta indica* (neem)
3. *Sapindus* sp. (soap nut).

4. *Eucalyptus* sp.
5. *Pongamia glabra*
6. *Tribulus* sp.
7. *Glyncidia* sp.

Tamarind provides a rich supply of nectar. Pollen to the bees is supplied by many plants such as Sorghum, maize, roses, millets, varagu and tenai and various fruit yielding plants.

Bees are the social and colonial insects. The culture of bees for the honey is termed as Apiculture. The prominent varieties of Indian bees are Apis *dorsata* and *Apis indica.*

Honey is defined as an aromatic, viscid sweet product modified by the honeybees. It contains 20 percent moisture, 60-75 percent invert sugars, dextrose and sucrose. Minerals like iron, copper, manganese, magnesium, sodium, potassium, calcium, phosphates, amino acids, vitamins, acids etc. are also present in honey.

It is a rich assimilable energy. It is used with fruits and salads and in canning and preserving. As medicine: it is used as a carrier in ayurvedic siddha system of medicines. It is a laxative and a blood purifier. It is also used in many religious rites. It is used in making alcoholic drinks, skin and beauty lotions. It is an ingredient in cigarette, chewing tobacco, and in the manufacture of chewing gums.

Bee wax is an important by product of the beekeeping industry. It is produced from the old combs. Bee wax is an yellowish solid with an aroma resembling that of honey. It is insoluble in water. It becomes plastic when warmed and brittle when cold. It is used in the manufacture of many items of cosmetics like beauty lotions, creams, lipsticks, ointments, polishes of boots, floor, furniture, paints and varnishes, inks, electrical insulating apparatus and candles.

Lac cultivation can be carried out in the forest where suitable host trees are grown. Host plants are Palas (*Butea monosperma*) Kusum (*Schleichera oleosa*) Ber (*Zizyphus* sp. Shorea.

The beautiful carmine red dye cochineal is made from the dried bodies of these insects *Dactylopicus coccus* and *D.tomentosus*

It contains 10 percent of carminic acid, which is used for colouring beverages, cakes and sweets. It is used for dyeing materials like wool, silk and leather It serves as a cosmetic and for treating whooping cough.

Fat obtained from silkworm are used in the manufacture of soaps. The castings of the insects serve as manure.

Marine Products

Marine environment is a vast area which contributes many marine organisms both plants and animals. Some organic material is carried to the sea by rivers and is utilized for the life in the seas. India has world's one-fifth marine area with rich fauna.

Marine resources of India categorized as:

1. Non living
2. Living

1. Non Living resources

Drugs

Marine environment has many plants and small animals recognized for the manufacture of important live saving drugs in India. *Gracilaria* sp. with sufficient prostaglandins. Bioactive substances are also present which are useful in curing many incurable diseases. Marine algae have antifertility properties and contain prostaglandins is known for antifertility characteristics. Bioactive substances are also present which are useful in curing many incurable diseases. Lesser quantitative concentration and difficulty in extraction are the major hurdles in deriving most of the chemical economically. Commercial exploitation have been successful for certain chemicals i.e. sodium, chlorine, magnesium, bromine, calcium and sulphur. Research has been carried out for the derivation of potassium, Iodine, Uranium and gold from sea water.

Rare chemicals are dissolved in sea water which are not easily available on land could be derived by efficient recent technologies. Trace elements are present in marine organisms. Cultivation and harvest of these organisms provide a way for getting the trace metals dissolved in seawater by biochemical methods.

Chemogenous deposits are formed due to rapid chemical reactions on the floor of the ocean.(i.e) Indian coasts. Barium nodules are seen in West Andaman and Laccadive Island. Phosphorite nodules are seen in north Andaman and polymetallic nodules in the Central Indian Basin. Phosphate deposit with vital presence of valuable uranium is present. India rank's 13^{th} position in the world's phosphate deposits. Algal and politic lime stones are present in Sourashtra through Goa to Kerala coast. Gypsum crystals are found in the inner shelf off the Maharastra coast. Heavy mineral deposits are available in larger amount than that of land territory. Mining sites have also been identified some areas. Occurrence of heavy mineral concentrates usually known as "Black sands" have been reported in many localities of Indian coast. It contains ilemenite, rutile, zirlan, magnetile, monazite, garnet, Kyanite, and tin in significant proportions. Most of the terrigenous deposits occur along the coast of Kerala between Quilon and Cape Comorin. The deposit contains 17 m tones of ilmenite, 1m tone of rutile, 1.2 m tones of zincon and 0.2 m monazite in the Ratnagiri coast (Maharashtra) Tirunelveli, Ramnad, Thanjavur (Tamil Nadu) Visakhapatnam, Yarada, Waltair, Bhimunipatnam (Andhra Pradesh) and the coastal areas of Orissa. Almost 25km stretch along the coast Neendakarai to Kayankulam of Kerala have richest deposit of offshore heavy minerals. Illmenite concentration is from 17 to 79 percent in the Ratnagiri coast. Along the western shelf from the Gulf of Kutch, relict sands are present which consists of oolites and biogenous

material. Other species are corals and deep sea pelagic oozes. Much amount of biogenous deposits are seen in the Gulf of Kutch and Vambanad lake (Kerala) production of these are ranging from 1million to 2 million tones. Biogenous residues and calcareous sands are found to be 1135 m tones in the Lakshdweep Islands. Ornamental semiprecious stones has an important place in ornamental shell in exporting.

The formation of petroleum and natural gas represents a process of bacterial and thermal decomposition or fission. In the long-term process of this action contribute to petroleum fields formation under the seas. It would be about roughly one million years. Hydrocarbons of different length with single, double and triple bonds gives arises various organic compounds. Gums and asphaltenes of high molecular weight organic compounds give arise to the oils. The sulphur and nitrogen compounds are replaced by sulfur or nitrogen atoms. By anaerobic action of bacteria (biological reduction) at lower temperature gives rise to various organic substances, which transforms them into fatty acids, methane, ethane and hydrocarbons.

Volcanic rocks get weathered off, during which various compounds are dissolved in the waters (i.e) alkaline earth metals like calcium and magnesium and also alkali metals sodium and potassium . The potassium, calcium, sodium along with magnesium, dissolved carbon dioxide and sulfur compounds are carried to the oceans from the rivers. It ultimately forms various salts. Least soluble carbonates and sulfates occur in small concentrations. Around 40 percent of the sea bed is being covered by foraminiferal ooze, formed from the shells of dead protozoa.

The salts and mineral constituents formed differ from one another in their chemical composition. Carboniferous rocks are deposited in the shore basin and in the middle region. Sulfates and chlorides are deposited in the interior basin.

Living resources

In Fisheries, India occupies the 8^{th} position in the world in terms of total annual catching. It is estimated to be 11.4 million tones per year. Marine environment provides various marine organisms both as the source of food and other commercial values. Natural resources like marine fishery resources are gifts of nature. Fishes are utilized for the preparation and extraction of various antibiotics, drugs, oils etc. Cod-liver oil, vitamin A and other substances are extracted from fishes.

Diatoms are main protein rich organisms and are the producers of the marine environment. The total annual production of diatoms of all seas are calculated to be $1.2 – 1.5 \times 10^{10}$ tones. Diatomin food reserve present in diatoms is rich in vitamin A. The diatom along with blue silica is used in various fields such as preparation of juice, syrup and varnish.

Human population is increasing fast. People may die due to starvation or diseases or by malnutrition. In this context plankton could be a major food source with rich protein reserve.

Plaktons includes both plants and animal (i.e) phyto and zooplankton. Diatoms when dies sink to the bottom to form diatomaceous earth. This may develop into new petroleum grounds.

Minute form of corals, coral reefs and coral polyps are seen at depths of 10 to 50 m. Some are colonial in nature and some are solitary. Cup like skeleton secretes calcium carbonate. There are different types of corals and various colours like blue, pink, lilac, violet, eosine, red or tan. They are termed as "sea flowers" because of their lovely colours. There are two types of corals "false corals" and "true "or "stony corals". Eg. Sea fans, sea whips and sea feathers with a skeleton in the form of scattered horny or calcareous spicules and black horny central axial hornyskeleton. Ammonium carbonate are secreted around the ectoderm.

Some corals are highly priced for their decorative value.

Corallum sp. is considered as a precious stone. It has sacred properties. This type were exchanged for emerald, rubies and pearls by the people of China and India.

Italians wear these coral as necklace to safeguard their children from evil and prevent from female sterility. Red coral is used in medicine in ancient times. Organ pipe coral (Tubipora) has some indigenous qualities and used in curing many diseases. Black corals are weared as preventive measures of rheumatism by the Japanese and Malayans. Chunks of coral skeleton are used as building blocks and for metallic roads. These corals are porous which keep the houses cool. These coral skeleton serves as raw materials for the preparation of lime, mortar and cement due to the presence of high calcium carbonate content. Coral lime stones are rich in magnesium and are used in the manufacture of cement and in carbide. Valuables fauna are also present in coral reefs (i.e) Octopus, sea urchins, sea slugs, trochus, oysters and turtles.

Ocean skaters feed on the dead remains of medusae, sea anemones, crustaceans, fish eggs and larvae.

These are important protein rich food source for many animals.

Sea cucumbers belong to invertebrate phylum Echinodermata. They are generally termed as holothurians. They have high protein content. The processed body wall of holothurians is known as "beche-de-mer". The protein content of it varies from 35-65 percent. Minerals like calcium, sodium, potassium and iron are present in these animals. Dried body wall cut into small pieces are added to soups which impart delecious flavour. It is also eaten as bits. In some parts of Indo pacific regions the holothurians are eaten raw. Beche-demer is a good foreign earner. It is exported from India since 1975. Holothurians are used medically. It is also used to suppress the growth of microbes.

Fish is an important and indispensable item in the diet of certain people. Fish and its products are highly nutritious and are excellent source of proteins, minerals and vitamins. Energy level is 193 k.cal/100gms. Around 90 to 100 percent of fish protein are digestible. Hence it is included in the diets of patients suffering from digestive disorders and ulcer. Vitamins B6, B12, Biotin and Niacin and minerals such as phosphorus,

potassium and iron are present in fish. Moreover trace elements (minerals) like Cu, Zn, Mn, Co, molybdenum and selenium are present in fish eggs. They have high iodine content.

The products of the marine environment both non living resources and living resources are beneficial to the mankind for his day to day activities. Living natural resources are numerous or larger in amount in the marine environment. They are as such used as raw material and also their by products are commercially, economically available for the benefit of man kind.

Anti fouling

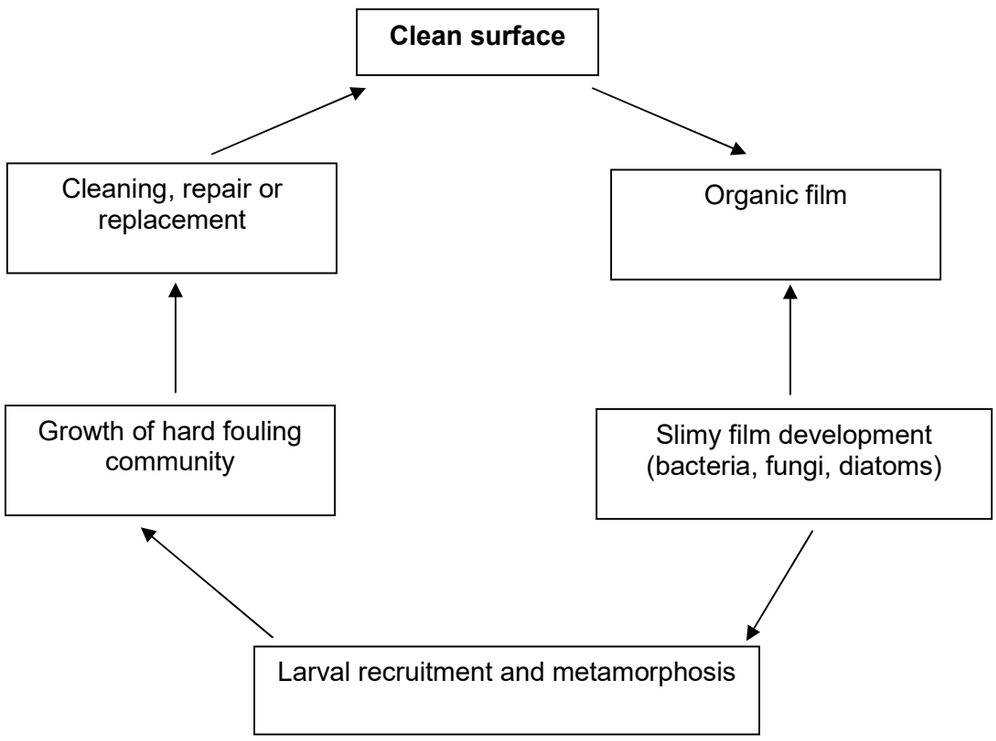
Fouling is termed as the process of attachment and growth of plants and animals to all submerged objects in the sea. E.g. Marine structures, buoys, piers, jetties etc. Attachment over the undersea surface of the materials is done by a community of plants and animals.

The important groups which initiates fouling are bacteria and diatoms. These groups attached to the surface begin to multiply rapidly and form a slimy film. Organisms of the entire animal kingdom from Protozoa to Chordata and all major groups of marine plants. Such as barncles, mussels, other mollusks, bryozoans, hydroids, tunicates, serpulids (tube worms), sponges, echinoderms, sea anemones, corals, arthopods etc. from part of the fouling communit.

When a solid surface is exposed to sea water, it immediately adsorbs both organic and inorganic matter present in sea water forming a thin film over the surface. Within 30 minutes, bacteria will settle on the surface and form colonies. A few dominant species, colonize the surface within 48 hours and begin to secrete polysaccharides and proteins which form a slime layer or coating over the entire surface. The quality of coating varies with the object such as metals, wood, glass, plastic fibre glass etc. This slime layer leads to the attachment of many fouling organisms, such as diatoms, algae, smaller animals (protozoans), barnacles cyprids (larvae of barnacles and the larvae of sedentary polychaetes).

Many organisms are sessile in nature which, invade the surface and settle inside the pits or holes. Each organism provides a new surface for the other groups to settle themselves.

FOULING CYCLE



In addition to bacteria, diatoms belonging to 34 different genera also cause fouling. *Navicula* sp. and Skeletonema sp. are the most dominant species one among befouling community.

Some animals like holothurians and sponges posses effective defense mechanism and synthesis bioactive substances have antifouling properties.

Experiments were conducted already to confirm antifouling activity of holothurians and sponges.

Commercial antifouling paints are currently made which contains various types of toxic biocides. Natural products (plants and animal materials) are used in the control of befouling. Both terrestrial and marine natural products form a fruitful source of ecofriendly antifouling compounds. Some marine organisms like sponges, corals, ascidians, bryozoans, holothurians keep the surfaces clean by producing metabolites. Sponges have antifouling compounds and these animals are rich in bioactive substances such as terpenoids and steroids.

Control of Biofouling

Scrubbing is the oldest technique known to man. Ships and boats are dry docked and various types of mechanical means are employed for scrapping the hull and removing all the attached organims. Eg: Rotary powered brushes are used for quick removal. In large types of ships, scrapping is done inside the water.

There are various kinds of paints which act as repellents or toxic to various fouling organisms. These paints prevent the formation of a slime layer. These paints provide only temporary solution (i.e) for about one year. Occasional scrubbing is required. Antifouling paints which are now being applied are copper compounds, organotins containing arsenic, dieldrin, DDT, mercurous and zinc compounds. Plastic films are also used to control fouling. Repellent extracts from marine plants and animals are free from fouling. Tannic acid, benzoic acids and several other components have only temporary effect on the fouling activity in the inferior piping system of power plants or heat exchangers. The brushes which are used for cleaning the pipes themselves get fouled with micro organisms. Offshore platform also get fouled which require inspection, maintenance and repair at an enormous cost. Antifouling paints have several draw backs. It contains a lot of water soluble resins, pigments, metal salts which begin to leach when comes in contact with seawater. With long time it loses their effectiveness.

Based on the action of the paints, they are classified as

1. Continuous contact
2. Soluble matrix.

Continuous contact type of paint have considerable poison in the surface layers of the paint. These paints are coated as thin layer.

Soluble matrix type of paint contain lower concentration of poison but it has a porous structure which allows the poison to reach the surface from the paint. This is applied as thick coating. This type is more effective. Both types are effective for two years only. Further more, the vessels should be dipped or immersed in sea water before the paints are dried or otherwise the paint surface becomes harden and seals the porous nature, prevents the flow of poison on the surface making it ineffective. Also the vessels and all the equipments should be prepainted first before the antifouling paints are applied to prevent corrosion. Scientists have proved that organic compounds of tin is used in the preparation of modern paint which is more effective like cuprous oxide paints. Furthermore vessels or crafts are taken to low saline areas like rivers where all organisms could be killed.

The basic advantages of these paints are

1. They are not corrosive
2. They do not lose their effectiveness on drying
3. The boats need not to be launched in seawater immediately after painting.

Both direct current (DC) and alternate current (AC) are being used to control fouling. Cathodic protection is normally used and the steel become cathodic and thus gets prevented from corrosion. Cathodic polarization changes the chemical nature of the surface and prevents attachment, growth and activity of fouling organisms. Direct currents with alternate polarities are switched on to dislodge the animals along the cathodic side.

Electric currents in sea water also produce chemical agents like chlorine and hydrogen peroxide which inhibit biological growth.

High frequency sound wave (ultra sound) are used for sterilizing materials control of algal growth and even preventing birds from nesting in buildings. Ultrasonic devices in the range of 23-27 KH_z and 250-1000 watts are effective for some animals.

Magnetic fields are used for controlling fouling. Static fields have temporary effect on bacterial growth. Strong magnetic field decreases the permeability of the membrane of protozoans to water.

Many animals have positive effect to light. For eg. *Barnacle nauplli* get congregated towards a light source which can be used to eliminate them. Coloured lights are known to have a repelling effect on animals. UV light is most effective in controlling fouling repelling most of the organisms. But it's cost is high and moreover it is used in the open system which is not justified.

Radioactive material was incorporated with anti fouling coating using pigmented Mallium –204. This isotope emits soft beta ray with a half life period of about 4-5 years. The effect was better but in the health point of view it is not desirable to use in shipyard environment.

Man has observed various problems of bio fouling right from ancient times. He has used may kinds of indigenous herbs, oils and decoctions of plants as paints act as a repellent for fouling. All these were only temporary relief. However the boats and crafts were sun dried and the microbes were killed. But now-a-days the wooden crafts were replaced by steel iron rods which could not be sun dried or pulled out of the sea shore. Thus fouling control technology (FCT) has developed in the modern times. Most anti fouling technologies are limited for a specific period. Standard copper based antifouling paints are effective. This is also for a period of two years.

Many new paints with new combinations formulae have been marketed out throughout the world but all these paints are effective for a limited period only. Further research and challenges are to be faced by the scientist to overcome every FCT method. A best innovative ingenious method has to be developed.

Anticorrosive protected compounds

Corrosion is the loss of metal either as local or general loss of thickness. Internal corrosion may cause the loss of metal embitterment. When the water flows inside the pipe hydrogen sulphide is released which will corrode the pipelines.

The rate of corrosion is influenced by metal composition and surface condition. Temperature of the seawater plays an important role in corrosion. The salinity of the seawater corrodes the pipelines and sea ships. Corrosion rate increases directly with oxygen content. Suspended solids increase corrosion by an abrasive action on steel surface.

Special coating together with a cathodic protection system, dehydration of the gas, chemical inhibition are treatments known to prevent corrosion.

Anti corrosion coating provides a barrier between steel and sea water, which form electrical insulation. There are two types of coating.

1. Traditional
2. Modern coating traditional type includes coatings with hydrocarbon bond (i.e) coal tar pitch (or) petroleum tar. Modern coating is done with thermoplastics and thermo hardness. Other types of coatings are composite coatings with the thickness 5-6 nm made of a primer coat, or enamel coat, or reinforcing coat (minimum one).
3. Cathodic protection is an anticorrosion technique. It brings the electro chemical potential of the metal to a negative value, so that it is immune to corrosion. The drop in potential required to ensure cathodic protection is obtained by an electric current. The electric current may come from generator or by creating a batter with different potentials with the environment forming electrolyte. Cathodic protection is very essentials because of the following reasons.
    1. Production defects which escaped notice at the inspection
    2. Damage to the coating during handling and laying
    3. Electrical insulation characteristics of the pipe coating if deteriorates with time.

Oxygen, carbon dioxide and hydrogen dissolved in water drastically increase the corrosivity. Oxygen present in air reacts with iron causing corrosion. Carbondioxide in water reacts with air, forming carbonic acid, which causes “metal corrosion”. Hydrogen sulphide causes a reaction with steel forming iron sulphide which damages to the metal surface causing “sour corrosion”. The free hydrogen also causes hydrogen induced cracking in the pipeline and handling equipments.

Corrosion protection of structures using cathodic protection involves the application of current either through galvanic system or through impressing an external voltage. The structure will be polarized to a potential corresponding to the region or immunity. The potential of this should be maintained and monitored to avoid damage to the coatings on the structures. The monitoring should be continuous. Various devices are available (i.e.) non-automatic and automatic devices are used in cathode protection for adequate protection to the metals in service. They are rectifier and autotransformer control in non-automatic modes. Motor operated variac, magnetic amplifier, control, transformed potential, silicon controlled rectifier, microprocessor based system control etc. in automatic modes.

Sea Weeds

Many sea weeds live in rocky inter tidal zones. They are subjected to the stresses with exposure to air and weather conditions. They tolerate the effects of evaporative water loss, temperature and salinity changes.

Sea weeds when exposed to air, completely lose it's water content and becomes dry. When the tide is high the sea weeds take out the water from them. Sea weeds living in tide pools are exposed to changes in water temperature and salinity. In hot days water warm up and evaporates which in turn increases the salinity. When it rains, it is vice versa. The sea weeds are damaged by freezing. Seaweeds in general provides shelter for the invertebrates and provide a food source for marine grazing animals.

Life and reproductive phase of seaweeds are complicated. They are perennial and live for many years. Some seaweeds are annuals and they live for only one year. Annual seaweeds begin to grow in the spring and continue throughout the summer. During the winter, the blades of seaweeds are often wiped off. If the hold fast are able to survive in the winter in the following spring new blades begin to grow. But the perennial species lose their blades during the winter the growth is reduced.

Sexually they reproduce by joining specialized male and female reproductive cells called gametes. The adults have two sets of chromosomes. The diploid plants are called sporophytes and produce spores by meiosis. It is a type of cell division by which the chromosome number is reduced to half of the number. The new cells formed have only one set of chromosome (haploid cells). Sporophyte releases the haploid spores. These settle in bottom and grow into male and female plants called gametophytes. These are haploid which produce gametes (sperms) or (eggs). They may be retained in gametophyte plant body or released in the water. Eggs are fertilized when eggs and sperms fuse together and a diploid zygote is formed. This zygote develops into a diploid sporophytes and the life cycle is repeated. Seaweeds have a variety of reproductive life cycles. The diploid sporophytic plant produces haploid spores which in turn give rise to haploid gametophytes plant which produces haploid gametes sperms and eggs, which fuses to form diploid zygote. This gives rises to diploid sporophytic plant. Thus the cycle repeats. This type of reproduction is termed as alternation of generations.

If the gametophyte and sporophyte are similar in appearance it is termed as Isomorphic. If they are dissimilar it is termed as heteromorphic.

They also reproduce by asexual methods. It takes place by fragmentation or division. When the plant body breaks off, each fragment develops directly into new individuals. These are called as clones. They are identical to each other in their appearance and in general characters like that of the parental cells.

Pharmaceutical products

Various substances of animal and vegetable origin have been used since early days to alleviate the diseases of man and domestic animals. With the growth of organic chemistry attempts were made to isolate the active principles from crude drugs and to elucidate their constitution. These attempts have led to the development of synthetic

substitutes and new drugs, which have no counter parts among natural products. A large number of drugs natural and synthetic are now available for pharmaceutical purposes and their production testing and marketing constitute a fast growing industry. The drugs are classified according to the sources from which they are derived.

1. Drugs of vegetable origin
2. hormones and glandular products
3. Antibiotics
4. Drugs derived from marine sources
5. Synthetic drugs vitamins and biologicals.

Sea has long been known as an enormous store house of minerals and food materials . The organisms of sea are used in the treatment of many diseases mental illness and common cold.

Extracts of marine sponges particularly of Jamaica or Caribbean seas possess anti microbial, anti fungal, Ichthyotoxic and anti tumour substances. The *Verongia* sp. has bromine containing antibiotic substances is used as therapeutic agent against certain cancers. Corals belonging to the Phylum Coelenterata is known for antibacterial substances.

Red sea weed contains a compound elatol. It is an anticancer drug as it inhibits or arrests the cell division.

Certain sea anemone contains a powerful cardiac stimulant Anthopleurin A. It is an enormously complex polypeptide which contain 90 amino acids It is more powerful than commonly used heart stimulant. This has no side effects and it is 300-500 times powerful.

There is no acceptable substitute now for “heparin”. The anticlotting agent in human blood extracted from the lungs of cattle and intestinal mucosa of swine are present in sharks, crabs, lobsters, clams and scallops which are discarded as wastes.

The coenzymes in the liver of lemon sharks can accelerate the body’s defense mechanisms. Experiments done on rats and mice proved that when they were treated with shark liver extract there was a significant increase of phagocyte production.

Toxins

Dinoflagellates (single celled algae) release neuro toxins during metabolism. These toxins work interacting with sodium metabolism of humans. If these toxin are properly modified and controlled, they could be best used as medicine.

When diatom populations die, the shells (frustles) form a bed called “diatomite”. This is an indicator for the presence of petroleum. The diatomite with pure silica is used as filtering agent in the preparation of fruit juice, syrup and vanish. It is also used in the boilers electric ovens and refrigerators as insulators: It is used as polishing agent for

precious metals in the separation of paraffin wax from petroleum and in the manufacture of concrete where 1-3 kg of diatomite is mixed with 50 kg of cement.

Planktons are important valuable human food source. There is a high amount of protein content in planktons (60% of the dry weight), lipids 15% and carbohydrates (2-3%) and ash 20%. Dried copepods are converted into human food and is better than beef and other animal flesh. Planktons are good source for pharmaceutical industries.

Corals of intricate design and beauty are used as ornamentals. Corals are actually the skeletal remains primarily of calcium carbonate secreted by living coral polyps (colonial animals). These are also useful in preparation of various pharmaceutical product. They are rich source of calcium and carbonate.

UNIT IV Solar Energy - photovoltaics, solar cookers, heaters, lantern, heat exchangers, wind energy, ocean thermal energy, energy extraction from waves and tides.

1. Sun

Sun is a sphere of hot gases having a diameter of 1.39×10^9 m. It is at a distance of 1.5×10^{11} m from the earth. It rotates on its axis about once in every four weeks. The equator takes about 27 days and the polar regions take about 30 days for each rotation.

The temperature in the central interior region of the sun is around 8×10^6 to 40×10^6 K .

Solar radiation received on the earth's surface is approximately 8×10^{16} W and is more than 10,000 times the present world energy consumption.

2. Solar Energy

The solar energy is used for natural as well as many technological processes.

They are

1. Helio chemical process
2. Helio thermal process and
3. Helio electrical process

The helio chemical process manifests life on this planet producing food by converting carbon dioxide into oxygen through photosynthesis. The helio thermal process offers thermal energy for domestic, commercial and industrial applications using thermal conversion devices. The helio electrical process provides electric power using photovoltaic converters.

Before going in detail to both the thermal and electrical processes, it is good to know the basic of the following

1. **Beam radiation or direct radiation**
2. **Diffuse radiation or sky radiation**
3. **Total solar radiation**
4. **Irradiance**
5. **Solar time**
6. **Altitude angle**
7. **Slope**
8. **Declination.**

Beam Radiation or direct radiation is the solar radiation received from the sun without having been scattered by the atmosphere.

Diffuse radiation or sky radiation is defined as the solar radiation received from the sun after its direction has been changed due to scattering by the atmosphere.

Total solar radiation is known as the sum of the beam and diffuse radiation on a surface. In general measurements of the total radiation on a horizontal surface is often referred to as global radiation.

Irradiance is the rate at which radiant energy is received on a unit surface area.

Solar time is the time based on the apparent angular motion of the sun across the sky.

Altitude angle (α) is defined as the angle between sunrays and a horizontal plane.

Slope (β) is the angle made by a surface with that of the horizontal plane. It is taken to be positive for surfaces sloping towards south and negative for surfaces sloping towards north.

The declination is the angle between the line joining the centers of the sun and the earth and its projection on the equatorial plane.

Helio thermal systems

Solar thermal energy conversion systems are classified into the following categories of applications in the order of rising cost and complexity.

1. **Low temperature applications (below 100°C) – for most common applications such as water heating, air heating, drying and desalination**

2. **Medium temperature applications (100 to 300°C) – for the applications like steam generation for industrial use and refrigeration**

3. **High temperature applications (above 300°C) – for power generation**

3. Low temperature applications

Solar water heaters

A solar collector is a device designed to absorb incident solar radiation and to transfer the energy to a fluid, which may be either liquid or air, passing in contact with it. The most common liquids used are water or a water-ethylene glycol solution. The most common gas used is air.

The major type of solar collector is a solar flat plate collector, which use both beam and diffuse solar radiation. They neither require tracking of the sun nor require any maintenance.

A flat plate collector generally consists of the following components

1. **Glazing**
2. **Absorber plate**
3. **Header, tubes, fins or passages**
4. **Insulation**
5. **Container or casing**

Glazing is formed of one or more sheets of glass, which protects the other components from varying meteorological conditions. Its major function is to admit the solar radiation and to reduce the upward loss of heat. Glazing transmits the incoming long wave radiations emitted by the high temperature source (sun) (transmittance more than 80%) and does not admit (transmittance negligible) emitted by absorber plate to go out.

Absorber plate absorbs a maximum of solar radiation and transfers it to the working fluid. It may be flat, corrugated, or grooved, to which the tubes, fins or passages are attached.

Header, tubes, fins or passages are used for conducting or directing the heat transfer fluid from the inlet to the outlet.

Insulation minimizes heat loss taking place through the back and sides of the collector.

Container or casing surrounds the foregoing components and keeps them free from dust and moisture. It is to be noted that mounting will not be possible, if all the components of the collector are arranged in a container or casing.

Sunrays striking the absorber plate are absorbed, which results in the temperature rise of the absorber plate. Heat transport fluid is circulated through the tubing, which is in intimate contact with the absorber plate. The heat is transferred from the absorber plate to the heat transport fluid. The thermal insulation behind the absorber plate and the transparent cover sheet prevent loss of heat to surroundings.

Other solar collectors

Ordinary flat plate collectors are mostly not practical for temperatures more than 70°C because of their high heat loss coefficient. When higher temperatures (> 70°C) are desired, the heat loss coefficient should be reduced. Some of the alternatives to the conventional collectors that are widely accepted are described below.

Evacuated tube collectors

Reducing or suppressing the heat loss by convection from the glass cover at the top can increase the performance of a liquid flat-plate collector, which will be possible by creating a vacuum between the glass cover and the absorber plate. So, one can use a glass tube as the cover because only a tubular surface is able to withstand the stresses introduced by the pressure difference.

Many types of evacuated tube collector designs have been developed. The widely used, common design consists of a number of long cylindrical flat-plate collector modules located side-by-side. Each module has a metal absorber plate with two fluid tubes placed in an evacuated, cylindrical glass tube. The absorber plate has a selective surface coating on it. Glass and metal seals are provided between the fluid tubes and the end cover of the glass tube. The two tubes are joined at the other end inside the glass cover and form a 'U', with one tube acting as the inlet tube and the other as the outlet tube.

Transparent insulation honeycomb collector

The heat loss on the top glass cover can also be reduced by introducing a transparent insulation in the form of a thin honeycomb structure between the absorber plate and the cover. Glass or plastic materials like polymethyl-methacrylate, polycarbonate or polyethylene are used for making the honey comb structure. The most widely used structures are arrays of capillary tubes and square cross section cells.

The diameter of the openings for water flow is 3 to 4mm. The thickness of the walls is about 100 μm if it is a glass and 20μ m if it is a plastic. The total thickness of the structure is about 10 cm. The distance of separation between the honeycomb and absorber plate is 1 or 2 cm.. These honeycomb cells ensure that the solar radiation is essentially scattered in the forward direction as it penetrates the honeycomb structure after a series of reflections and refractions. The presence of this honeycomb structure effectively suppresses both the convection and the re-radiation losses from the absorber plate to the surroundings. The loss coefficient at the top cover glass also is reduced significantly.

Solar air heaters

Air is generally used as a heat transfer fluid in many types of energy conversion systems. Solar air heater warms the air. Warm air can be used for drying applications under controlled conditions.

The principle of solar-air collector is the same as that of the liquid flat-plate collector. Air is circulated in contact with a black radiation-absorbing surface which is usually over-lid by one or more transparent covers for heat loss reduction. For practical and technical reasons, heat collected is generally stored by transferring it to a pebble bed. Night air heating is then accomplished by circulating cool air through the same warm pebble bed.

Solar air heaters have been made in a variety of designs. Some of the absorber surfaces used are overlapped, spaced, clear and black glass plates, single smooth metal sheets, flow-through stacked screens or mesh, corrugated metal plates or finned metal sheets, etc placed beneath the glazing. In others air passing beneath the absorber plate or underlying air passage reduces downward heat loss and one or two covers of glass or transparent plastic resistance is used to create upward convection and radiation losses.

Air-heating collector designs are classified into six categories according to the type of absorbing surface. They are

1. **Simple flat plate collector**
2. **Finned plate collector**
3. **Corrugated plate collector**
4. **Matrix type collector**
5. **Overlapped transparent plate type collector**
6. **Transpiration collector**

Simple flat-plate collector

This is the simplest and most commonly used type of collector. It is composed of one or two glazing over a flat absorbing plate backed by insulation. The path of airflow may be either above or below or both above and below the absorber plate. Three types of air heaters are in operation. They are

1. **Overflown absorber air heater**
2. **Underflown absorber air heater**
3. **Two pass air heater**

In over flown absorber air heater there is an absorber plate, which is insulated on the rear side. There is a single transparent cover on the exposed side. The air flows between the absorber plate and the transparent cover. The efficiency of such air heaters is expected to be low compared to that of the conventional direct type air heater since there will be high heat loss through the transparent cover to the outside.

In under flown absorber air heater airflows between the absorber plate and the bottom insulation. Because of this air flow path, the top and bottom heat losses may be reduced considerably.

In two-pass solar air heater the air is allowed to flow over the absorber plate, and also then under it, thereby increasing the efficiency, since the air between the absorber plate and the cover plate is cooler.

In a single pass solar air heater, air is made to flow either in a duct between the absorber plate and rear plate or between the transparent cover and the absorbing plate. Hence, the thermal losses are higher. In two-pass solar air heater, these losses are reduced.

Finned-plate collector

This is a modified version of a flat plate collector, in which the heat transfer co-efficient is increased by employing fins on the flat plate absorber. In certain designs the surface is made directionally selective for enhancing the heat transfer and hence the efficiency of the collector.

Corrugated-plate collector

This is another version of the simple flat-plate design. In this type, the absorber is corrugated either in rounded troughs or V-troughs. This causes an increase in the heat transfer area which may make the surface directionally selective.

Matrix type collector

In this design an absorbing matrix is placed in the airflow path between the glazing and absorbing back plate. The matrix material may be an expanded metal plate, cotton, gauze or loosely packed porous material. This type of collector offers a high heat-transfer to volume ratio and low friction loss.

Overlapped transparent plate type collector

This type of collector is composed of a staggered array of transparent plates, which are partially blackened. Airflow is effected between the overlapped plates.

Transpiration collector

The transpiration or porous bed design is a variation of matrix type, in which the matrix material is closely packed and the back absorber-plate is eliminated. The airflow usually enters just under the innermost cover and flows downward through the porous bed and into the distribution ducting. Transpiration collection is of two types.

The first type is commonly known as non-porous absorbers. The air stream does not flow through the absorber plate. Air may flow above, below, or both and below the absorber plate. In the second type of air heater, known as porous bed absorbers, the air passes through the absorbing material that includes slit and expanded metal, transpired honeycomb, and overlapped glass plate.

Solar cookers

Three types of solar cookers are available. They are

1. **Flat plate box type solar cooker**
2. **Multi reflector type solar oven**
3. **Parabolic disc concentrator**

Flat plate box type solar cooker

It is the simplest of all designs and hence widely used. The major components of this cooker are reflecting mirror, glass covers, cooking pots and cooking tray. The transparent glazing materials permit the passage of short wave length of solar radiation. These waves reach the blackened cooking tray. As a result the temperature in the cooking tray increases. The cooking pots, which are also black painted, are placed inside with food material, get heat energy and food is being cooked.

The glazing materials are opaque to most of the long wavelengths coming from relatively low temperature object. This causes the green house effect. As the upper cover of the cooker has generally two glass sheets in parallel the heat losses through re-radiation is minimized from the blackened surface. The loss due to convection is minimized by making the box air tight by providing a rubber strip all round between the upper lid and the box. Insulating materials like glass-wool, paddy husk, sawdust or any other material are filled in the space between blackened tray and outer cover of box, which minimize the heat losses due to conduction. Nowadays, the amount of solar radiation intensity is increased by providing reflecting mirror.

Absorber tray is painted dull black so that it can withstand temperature inside the cooker as well as water vapour coming out of the cooking utensils. The top cover contains two plain glasses each 3 mm thickness fixed in frame with about 20 mm gap between them. The entire top cover can be made tight with padlock. Neoprene rubber sealing is provided around the contact surfaces of the glass cover and the collector box. A small vent for vapour escape is provided in the sealing. Collector area of the solar cooker is increased by providing a plane-reflecting mirror equal to the size of the box. It is hinged on one side of the glass frame. A mechanism is provided which adjust the reflector at different angles with the cooker box. About 25°C rise in temperature is achieved inside the cooker box when reflector is adjusted to direct the sunrays into the box. During winter, when sunrays are much inclined to horizontal surface, reflector is a most useful addition. Overall dimensions of a typical cooker are 60 x 60 x 20 cm height. This type of

cooker is termed as family solar cooker as it cooks sufficient food materials for a family of 5 to 7 people.

The temperature inside the solar cooker with a single reflector is around 70 to 110°C above the ambient temperature. This temperature is enough to cook food slowly, steadily and surely with a delicious taste without loss of nutrients. Maximum air temperature obtained inside the cooker box is 140°C in winter and 160°C in summer. The cooking duration depends on season, time of the day, type of the food and depth of the food layer. It ranges from 1 to 4 hours. Cooking is done faster during summer than in winter. The best time of the day for cooking is between 11 a.m. and 2 p.m. The time required for cooking is reduced if metallic vessels with a tight lid and painted dull black from outside are used.

These cookers are simple to use and easy to manufacture. It is found that there is no problem of charring of food and no over flowing during cooking. No special attention is needed during cooking as in other devices. There is no fuel expenditure or recurring cost. They do not pollute the house or atmosphere. Vitamins in the food are not destroyed. Food cooked is nutritive and delicious. Orientation or sun tracking is not needed.

Factors such as problems of heat storage, regulation of temperature for cooking, the socio-cultural habits of the people and inadequate promotional efforts are the main reasons for the lack of interest shown in solar cookers inspite of their being functionally satisfactory and low priced.

Multi reflector type solar oven

In general, this type of solar ovens consists of a well-insulated semi cylindrical box made of sheet aluminium or galvonised iron and wood. It has two shells. The space between the shells is filled with insulation materials such as fibreglass or glass wool. The window of the oven consists of two transparent glass sheets with spacing. Eight reflectors made of silvered glass mirrors reflect light towards cooking pots, which are mounted on the cradles inside. The oven can be manually

tilted and oriented towards the sun. The maximum plate temperature in the oven reaches to 350°C in summer and 250°C in winter. Practically all types of cooking such as roasting, baking and boiling can be done within one and a half hour under clear sky conditions. The main advantage of this solar oven is that its efficiency is high because it has low wind heat transfer coefficient from the top and there are no chances of dust fall in the cooking pot. Moreover food remains warm if it is kept inside the oven for hours together even after sunset.

Parabolic disc concentrator

In this type of cookers, there is a reflector, which focuses the sunlight on the horizontal bottom of a kettle or plate. The reflector is supported in a rugged iron frame, which can be shifted from one place to another. This design of cooker is one of the simplest types and the cost is low, but the drawback is that the cook has to prepare the food out doors in the sun hence it is not favoured.

Solar ponds

In ordinary ponds, solar radiation penetrates the water to the bottom, and the water in the bottom gets heated. As a result of buoyancy, the heated water rises, and the heat is finally released to the atmosphere through convection and evaporation from its surface. But solar ponds are designed in such a way to reduce convective and evaporative heat losses and for collecting and storing useful amounts of heat. Because of large storage of heat and negligible diurnal fluctuations in pond temperatures, solar pond has a variety of applications like heating and cooling of buildings, green house heating, industrial process heat, desalination, power production, agricultural crop drying and the production of renewable liquid fuels such as ethanol.

Solar ponds may be classified into two types and they are

1. **Convective solar ponds and**
2. **Non-convective solar ponds**

Convective solar pond

In convective type, transparent membranes or glazings are used to cover the top portion of the ponds. These transparent tops allow transmission of sunlight and prevent evaporation losses. The bottom of the pond is black to absorb sunlight and it is insulated to reduce heat losses. The solar heated water can be removed late in the afternoon and stored in insulated reservoirs.

Non convective solar pond

In non-convective solar ponds, the heat losses are prevented by inhibiting the convection of temperature caused by thermal buoyancy. These ponds are stabilized by viscosity. The salt gradient pond is the most common type of non-convective solar pond. In this pond salts such as sodium chloride and magnesium chloride occur in high concentrations near the bottom, with decreasing concentrations toward the surface.

The salt gradient pond consists of three layers. In the top layer, convection takes place due to wind evaporation. No membrane or glazing covering is used in such ponds and as a result there is no loss of incident radiation. The second layer, which has the thickness of 1 cm, contains an increasing concentration of salt with increasing depth. This layer is non-convecting because the higher salt concentration with increasing depth negates thermal buoyancy forces. The third layer, which is at the bottom, is a convecting layer of essentially constant salt concentration and it acts as a thermal storage system. One of the common methods of extracting heat from such a pond without causing undesirable mixing is to place a heat exchanger just beneath the lower zone. Hot water can also be extracted from the bottom of the pond from one end and cold water is fed from the other end of the pond.

There are also other types of solar ponds namely shallow solar pond, partitioned solar pond, viscosity stabilized solar pond, membrane stratified solar pond and saturated solar pond, which are used on the basis of the required applications.

Solar stills

A device used for converting saltish water into potable water using solar energy is called solar still. Many types of solar stills are available.

Basin type solar still consists of a shallow blackened basin of saline water covered with a sloping transparent roof. Solar radiation that passes through the transparent roof is absorbed by water in the basin, which raises the temperature of the water. The water now losses heat by evaporation, convection, and radiation to the cover and by conduction through base and edges of the still. The evaporated water from the basin increases the moisture content in the enclosure which finally condenses on the underside of the cover, slips down into the condensate channels and through them out of the still for use.

4. Medium temperature applications

Industrial process heat

Industrial process heat is the thermal energy used directly in the preparation or treatment of materials. They are

1. **Process hot water,**
2. **Hot air**
3. **Process steam**

Hot water from the solar collector is directly supplied as process heat. Heat exchangers are also used.

Hot air systems are generally employed for drying or dehydration processes in industries. In this mode, the hot air, if sufficiently heated by solar energy can be directly supplied for drying the products.

Solar refrigeration

In solar refrigeration, water is heated in a flat plate collector array and it is passed through a heat exchanger called the generator. Then, the heat is transferred to a solution mixture of the absorbent and refrigerant. The refrigerant vapour is boiled off at a high pressure and goes to the condenser, where it is condensed into a high-pressure liquid. The high-pressure liquid is throttled to a low pressure and temperature in an expansion valve, and passes through the evaporator coil. Here, the refrigerant vapour absorbs heat and cooling is therefore obtained in the space surrounding this coil. The refrigerant vapour is now absorbed into a solution mixture withdrawn from the generator, which is weak in refrigerant concentration. This yields a rich solution, which is pumped back to the generator, thereby completing the cycle. The rich solution flowing from the absorber to the generator is usually heated in a heat exchanger by the weak solution withdrawn from the generator. This helps to improve the performance of the cycle.

As it is known, cooling is required during summer while the highest solar radiation is obtained. So, there is a seasonal matching between the energy needs of the refrigeration system and the availability of solar radiation. Unfortunately the installation cost of the solar thermal refrigeration systems is high. Though many experimental studies have been conducted, very limited commercialization has taken place.

5. High temperature applications

Solar radiation is reflected from an array of large mirrors (heliostats) situated at the top of a supporting tower. A fluid flowing through the receiver absorbs the concentrated radiation and transports it to the ground where it is used to operate the power cycle. The receiver can also be used to heat a liquid metal or a molten salt and this fluid can be passed through a heat exchanger in which steam for the power cycle can be generated. The power production from the central receiver power plants depends on the number and size of the heliostats, the receiver type, the receiver fluid and the height of the central supporting tower. It is to be noted that the cost of construction of this is

high. However, costs are likely to reduce with more operational experience.

Meteorological measurements

Accurate meteorological database with special reference to temperature, wind speed and solar radiation is needed not only to calculate the thermal losses due to the existing atmospheric conditions but also to predict the efficiencies of the solar heating systems. Suitable instruments are to be used for exact measurements and some of the instruments that are widely used are discussed in the following section.

Temperature measurement

A common instrument used for the measurement of temperature is the thermometer. Mercury thermometers depend on thermal expansion while bimetallic thermometers are based on the differential expansion of two metals. The electrical resistance thermometer is based on the variation in electrical resistance of a metallic wire with change in temperature and a thermocouple is based on the electrical current, which flows when two electrical conductors made of two different metals are joined together. All four types are used in temperature measurement.

Wind speed measurement

Instruments for measuring wind speed are called anemometers. If they are recording instruments they are known as anemographs. The most common type is the cup anemometer. The rate of rotation of the shaft to which the cups are attached indicates the wind speed and this is transmitted to a recorder or an indicating panel by either mechanical, optical or electrical means.

Solar radiation measurement

Solar radiation received at the earth's surface without change of direction, i.e. in line with the sun, is called beam or direct radiation. The radiation received at the earth's surface

from all parts of the sky's hemisphere (after being subjected to scattering in the atmosphere) is called diffuse radiation. The sum of the beam and diffuse radiation is referred to as total or global radiation.

Two basic types of instruments are employed for solar radiation measurements and they are

1. **Pyrheliometers, which to determine the beam intensity as a function of incident angle**
2. **Pyranometers, which measure the total hemispherical solar radiation.**

Pyrheliometers

A pyrheliometer is an instrument, which is used for measuring beam radiation. Most of the pyrheliometers used for routine measurements operate on the thermopile effect. In this instrument, the sensor disc is located at the base of a tube whose axis is aligned with the direction of the sun's rays. Thus diffuse radiation is essentially blocked from the sensor surface.

To measure the direct solar radiation, the receiving surface must be in alignment with direct solar rays, i.e. a line joining the sun and receiver. Three types of pyrheliometers are used to measure normal incident beam radiation. They are

1. **The Angstrom compusation pyrheliometer**
2. **The Abbot silver disc pyrheliometer**
3. **Eppley pyrheliometer.**

These Instruments provide primary and secondary measurements.

Sunshine recorder

The duration of bright sunshine in a day is measured by means of a sunshine recorder. The sun's rays are focused by a glass-sphere to a point on a card strip held in a groove in a

spherical bowl mounted concentrically with the sphere. Whenever there is a bright sunshine, the image formed is intense enough to burn a spot on the card strip. When the sun moves across the sky, the image moves along the strip. Thus a burnt space whose length is proportional to the duration of sunshine is obtained on the strip.

6. Tidal energy

Periodic rise and fall of the water level of the sea is referred to as tide. It occurs mainly by the gravitational attraction of moon and sun on the water on the earth and the oceans. It is estimated that about 70 per cent of the tide producing force is due to the moon and 30 percent is due to the sun. Thus the moon plays a major role in the tide formation.

Usually tides are characterized by their schedule and range. The tidal schedules depend upon the moon's rotation period. The lunar day is defined as the apparent time of revolution of the moon around the earth. It is to be noted that the moon rotates around the earth in every 24 hour and 50 minutes. During this time the tide rises and falls twice and this results in a tidal cycle that lasts 12 hour 25 min.

The tidal range (R) is the difference between the water elevation at high and low tides. It can be written as

Tidal range (R) = Water elevation at high tide - water elevation at low tide

Because of the changing positions of the moon and the sun in relation to the earth, the tidal range varies continuously. The tidal ranges on the earth also vary from place to place. It remains at the maximum during full moon and these high tides are called as spring tides. At the time of first and third quarters of the moon, it remains at its minimum. These small tides are known as neap tides. It is estimated that the time duration for a spring-neap tidal cycle is one-half of a lunar month.

The tidal energy can be tapped from coastal waters by installing dams that entrap the water at high tide and drain it at low tide, back into the sea. Thus power can be obtained by the turbines from both in and out flows of the water. The amount of energy available is very large and the total tidal power dissipated throughout the world is estimated to be 2.4 x 10^{6} MW.

Tidal power plants

Tidal power plants are in operation all over the world. Three main components are in a tidal power plant. They are

1. **The power house**
2. **The dam or barrage**
3. **Sluiceways**

The powerhouse consists of the turbines, electric generators and auxiliary equipments. The dam forms a barrier between the sea and the basin or between one basin and the other in the case of multiple basins. The sluiceways are used either to fill up the basin during the high tide or empty the basin during the low tide, as per operational requirement. These are gate-controlled devices. It is generally convenient to have the powerhouse as well as the sluiceways in alignment with the dam.

The generation of hydropower requires a difference in water levels. The power generation from tides involves flow between artificially developed basins and the sea. Accordingly, the tidal energy conversion system is classified into two types and they are

1. **Single-pool or basin system**
2. **Two-pool system**

Single pool systems are the simplest ways to generate tidal power and they can generate power only intermittently. The single-pool system is classified into two types and they are

1. **Simple single pool tidal system**
2. **Modulated single pool tidal system**

Simple single-pool tidal system has one pool or basin behind a dam. This dam is filled from the ocean at high tide and emptied at the low tide. Filling and emptying of the dam takes place during a short period of time. The filling of the dam occurs during ocean is at high tide while the water in the pool is at the low tide level. Similarly the emptying occurs when the ocean is at low tide and the pool is at high tide level. Thus the flow of water in both directions is used to drive a number of reversible water turbines. Each water turbine drives an electrical generator.

Modulated single-pool tidal system partially overcomes the deficiency of simple pool system by generating power more uniformly at a lower average head. It is studied that the work and power are proportional to h^2, where h is the average head. So, the turbine generators are relatively much smaller and operate over much longer period. The reversible turbines are allowed to operate during periods of pool filling and emptying instead of high and low tides only.

Two-pool tidal system requires two separate but adjacent basins. One basin is called as upper basin and the other is known as lower basin. Because there is always a head between the upper and lower basin, electricity can be generated continuously. Although there is a variable rate, electricity generation process is continuous. This system is much less dependent on tidal fluctuations and so there is uniform power generation.

Some of the major advantages of tidal energy are given below

1. **It is completely independent of the precipitation and so it is superior than hydro power generation**
2. **It operates on the bays and so it does not demand additional land area**
3. **It is free from pollution as it does not use any fuel**

4. **It has a unique capacity, to meet the power demand effectively when it works in combination with thermal and hydroelectric system**

Some of the major disadvantages of tidal energy are given below

1. **It's construction is costlier.**
2. **The navigation is obstructed.**
3. **The supply of power is not continuous mostly since it depends upon the timing of tides.**
4. **It can be developed only where natural sites are available.**

7. Wave energy

Wave energy is due to the interaction of the winds with the surface of the oceans. Hence it is one of the indirect ways of utilising solar energy.

The wave energy can be converted into mechanical as well as electrical energies. There are many concepts and mechanisms for wave energy conversion. They are

1. **Wave energy conversion by floats**
2. **High pressure accumulator wave machine**
3. **Dolphin type wave power machine**
4. **Dam, Atoll wave power machine.**

In wave energy conversion through floats the wave motion is horizontal, but the motion of water is vertical. The latter motion is made use by floats to obtain mechanical power. In this system, there is a large float that is driven up and down by the water within relatively stationary guides. The piston and cylinder arrangement is used as a reciprocating compressor. By means of air compression, the wave motion is converted into mechanical and then electrical energy.

In high pressure accumulator wave machines instead of compressing the air the water itself is pressurised. The

pressurised water is stored in a high-pressure accumulator or pumped to a high level reservoir. In practice this process is done by transforming large volumes of low-pressure water at wave crest into small volumes of high-pressure water by the use of a composite piston. This is connected to a turbine which drives an electrical generator.

In Dolphin-type wave power machine the major components of this system are dolphin, float, connecting rod and two electrical generators. The float exhibits rolling motion and vertical motion.

The rolling motion produces relative revolving movements between the float and the connecting rod. The other is having a vertical motion. Between these two motions, the later causes relative revolving movements between the connecting rod and the stationary dolphin. In both cases, the movements are amplified and converted by gears generating rotary motions that drive two electrical generators.

The operation of Dam-Atoll waver power machine is based on the action of waves as they approach atoll (Small volcanic islands) in an ocean. The waves wrap themselves around the atolls from all sides, ending in a period in the center. This drives a turbine before discharging laterally outward. This device overcomes some of the disadvantages of the other devices namely, complexity and fragility in heavy seas.

Some of the major advantages of wave energy are given below

1. **It is a free and renewable energy source**
2. **It is pollution free and protects coastlines**
3. **It minimises erosion and even helps to create artificial harbours**
4. **It does not require large land area unlike solar and wind**

Some of the major disadvantages of wave energy are given below

1. **Waves lack dependability**
2. **Scarcity of accessible sites for construction**
3. **Construction part is complicated and needs more maintenance and mechanical strength to withstand the enormous power of strong seas. Construction and maintenance is costlier**
4. **Biological growth of marine organisms on the devices**

8. Ocean thermal energy

The ocean is a huge reservoir of various useful and renewable energy resources. The utilisation of the temperature differences, which exist naturally between the upper and lower layers of water in the ocean, in a heat engine to generate power is known as ocean thermal energy conversion (OTEC).

Solar radiation is absorbed by the ocean water. The thermal energy is thus stored in ocean water at low temperatures (upto 27°C). At a depth below 1 km, there exist negative temperature gradient, which does not exceed 10°C. Ocean thermal energy converter converts these differences in ocean temperature to electrical energy.

A heat engine can be operated between two temperatures, T_1 and T_2. In the case of OTEC, T_1 can be considered as the temperature of warm surface water of the ocean and T_2 can be considered as the temperature of cold deep water of ocean.

The maximum theoretical efficiency of a heat engine operating between source temperature (T_1) and sink temperature (T_2) is called Carnot efficiency (η_C) and is given by

$$\eta_C = (T_1 - T_2) / T_1$$

It is known that the average surface water temperature (T_1) for tropical ocean water is in the range of 24 to 27°C. In deeper-water the temperature reduction rate is around 4 to 6°C per km. The temperature differences however are not uniform.

If the temperature difference of OTEC is assumed to be 20°C, the efficiency will be

$$\eta_C = 20 / (27+273) = 0.0667 = 6.67\%$$

where **T_1 and T_2 are expressed in Kelvin.**

There are two different methods for harnessing ocean thermal energy. One is the open cycle, also known as the Claude cycle, and other is the closed cycle, also known as the Anderson cycle.

In the open-cycle turbine system, water is the working fluid. The warm surface water is made to boil by lowering the pressure. No additional heat is supplied for boiling. The low-pressure steam produced is used to drive a turbine. The exhaust steam is condensed by the deep colder water and is discarded. A heat exchanger is not required in the evaporator. But in condenser it is necessary as there is direct contact between the exhaust steam and a cold water supply. Because of the low energy content of the low pressure steam, very large turbines or several smaller units operating in parallel are required to achieve the required electric power output.

In the closed cycle system, a liquid working fluid is vaporized in an evaporator. The working fluids used are ammonia and propane. The heat required for vaporization is transferred from the warm ocean surface to the liquid by means of a heat exchanger. The high-pressure vapour leaving the evaporator drives an expansion turbine. This process is similar to a steam turbine that is designed to operate at a lower inlet pressure. The turbine is connected to an electric generator in the usual manner. The low-pressure exhaust from the turbine is cooled and converted back into liquid in the condenser. The cooling is achieved by passing cold, deep ocean water, from the depth of 700 to 900 m or more, through a heat exchanger. The working fluid is then pumped back as high-pressure liquid to the evaporator, thus cooling the cycle.

The open cycle, which is older one, utilizes the vapour pressure of sea water itself as the working medium and has been demonstrated to be practicable. But, a closed cycle uses a

working fluid with a higher vapour pressure. The advantages of ocean thermal energy are

1. **It is a free and renewable energy source.**
2. **It does not require large land masses unlike solar and wind**

The disadvantages are

1. **High installation and maintenance costs**
2. **Large size of heat exchanger is required**
3. **Large amount of sea water is to be circulated**
4. **High cost of electrical energy obtained from OTEC plants.**

9. Wind energy

In the continuous search for clean, safe and renewable energy sources, wind energy is certainly one of the most attractive options. Wind is nothing but the air-in-motion. It is defined by its direction and its speed. Wind energy is a manifestation of the solar energy. Energy in the wind is converted into rotary mechanical energy by the wind-turbine. The rotary mechanical energy is used for several applications such as water pumping, flour grinding, and electricity production. Wind energy to electrical energy has become economically competitive in areas of favourable wind and wind-electric energy systems are now on the forefront of renewable energy utilization projects.

Wind farms are located in geographical areas which have continuous, steady, favourable wind in the speed range between 6 and 30 m/s. Annual average wind speed of 10 m/s is considered to be very suitable. It is studied that wind power is proportional to cube of the velocity of wind.

$$\text{i.e. } P \propto V^3$$

The total quantum of wind energy in the world is enormous. Wind farms are installed in suitable sites with several

wind-turbine-generator units. It is estimated that the efficiency of wind turbine energy conversion plants is about 30 per cent.

The components of wind energy conversion systems are turbine, generator, control system and tower. The turbine converts wind power into rotary mechanical power. It has aerofoil blades mounted on the rotor. The wind drives the rotor and produces rotary mechanical energy. The mechanical energy is converted into electrical energy by means of a generator. The control system is used to enable the automatic operation, keep the wind turbine aligned with the wind, engage and disengage the generator, govern the rotor speed, protect the turbine from over speed or damage due to very high winds and sense malfunctions and give warnings. The tower is used to mount all the components of wind energy conversion systems and it is usually of the lattice type or a steel or concrete shell.

Several types of wind-turbines have been developed, installed and are being operated successfully. These are classified into two main categories depending on their axis of rotation, relative to the wind stream. They are

1. **Horizontal shaft wind turbine**
2. **Vertical shaft wind turbine**

In the case of horizontal shaft wind turbine, the axis of rotation is horizontal and the aero turbine plane is vertical facing the wind. It is simple in principle, but the design of a complete system, especially a large one that will produce electric power economically, is complex. Horizontal shaft wind turbines are sub classified as single bladed, multibladed and by-cycle multiblades type. The horizontal axis types generally have better performance. They have been used for various applications, but the two major areas of interest are electric power generation and water pumping.

As far as the vertical shaft wind turbine is concerned, the axis of rotation is vertical. It is to be noted that the sails or blades are also in vertical position. The vertical shaft wind turbine is sub-divided into two major types and they are Savonius or 'S' type rotor mill and Derrieus or 'D' type rotor mill. The advantages of vertical axis wind turbines are

1. **They will react to wind from any direction and therefore do not need any specialised equipment to turn the rotor according to the wind direction**
2. **They require less structural support as heavy components (like gear box and generator) can be located at ground level**
3. **The rotor is not subjected to continuous cyclic gravity loads, since the blades do not turn end over end.**

The advantages of wind energy are

1. **Renewable source of energy and non polluting in nature**
2. **No fuel provision and transport**
3. **Less costly on small scales (upto few kilowatt system)**

The disadvantages are

1. **Power generation fluctuates**
2. **High overall weight**
3. **Large areas are needed**
4. **Noisy in operation**
5. **High maintenance cost.**

UNIT V - **Human resources, bullock, horse, cattle bio energy spectrum, biomass gasification biogas, alcohols, petroleum and its derivatives, fire wood, thermal and hydrodynamic energy, alternate proteins, non converntional food resource, food security**

1. Human Resources

Population density is a key factor in a sustainable living. All humans have an impact on their environment by consuming energy, occupying space, utilizing resources and producing waste. Though the planet could physically fit many times the current population, the corresponding quality of life would be unbearable, overcrowded, undernourished and ravaged by disease. In order to

maintain a sustainable future for everyone, population growth should be managed.

The world human population is more than 6 billion. It took about 3.5 million years, to reach a population of one billion in the year 1860. But it took only 136 years to add five billion persons.

World population reached 6.1 billion in mid-2000 and is currently growing at an annual rate of 1.2 percent, or 0.07 billion people per year. By 2050, world population is expected to be between 7.9 billion (low variant) and 10.9 billion (high variant), with the medium variant producing 9.3 billion.

2. Bio-energy

India is a predominantly agricultural country and its 80 percent population lives in villages. Though we are rich in natural resources we are being troubled by energy crisis. Bioenergy is the major rural oriented energy source and can be used by any person.

Biomass includes all plant and animal matter on the earth's surface. Biomass such as crops, trees or dung are used to generate energy, like heat or electricity. This energy is called bioenergy.

Modern bioenergy is clean, efficient and sustainable. Austria now uses bioenergy to a total of 13 percent of all its energy needs and the United States generates 3 percent of its electricity from bioenergy. Bioenergy is the World's most important renewable energy and is quietly getting prominence.

Biomass being a renewable energy can be moved around and stored. It may be commercially processed into a range of fuel products including wood chip, pellets, bio-oil, biogas, methanol and ethanol.

Solid, liquid and gaseous biofuels can readily replace fossil fuels for heat energy transport fuels and electricity.

Biomass feed stocks may be used directly or indirectly as a fuel. In practice these fall into two main categories:

1. Dependent biomass resources
2. Exclusive biomass resources

Dependent biomass resources, are the ones arising as by-products of their activities; Examples are wood residues and recovered wood waste, straw, poultry litter, forestry residues, livestock slurry, sugar cane biogases etc.

Exclusive biomass resources are energy crops grown specifically for fuel. They are short rotation tree crops (single stemmed or coppiced), herbaceous (C4), grasses or whole crop cereals.

Electrical generation centers through bio-energy plants can be located where it is needed. It can be fitted into the existing electricity distribution network. Bio-energy can be used to generate electricity as and when required with a high degree of reliability. This concept is important especially when new electricity trading arrangements are being introduced.

Bio-energy projects are relatively small-scale, usually supplying electricity to distribution networks. This is known as embedded generation. Generating electricity locally has significant advantages in avoiding energy losses in long transmission lines and in reducing or avoiding the costs of reinforcing or upgrading electricity distribution systems. This will limit the cost and environmental impact of fuel transportation,

Our state has a livestock population of about 18.3 million. This animal wealth produces about 37 million kgs animal dung, which has a potential of producing about 1.2 million cubic meter bio-gas. This huge amount can suffice the cooking fuel requirement of about 50 lakhs families.

Livestock are an important component of an agro ecosystem. For instance, livestock provide the critical energy input to the croplands required for ploughing, threshing and other farm operations. Animal dung provides essential nutrients required for soil fertility and crop yields in the form of organic manure.

Bio-energy involves CO_2 emissions while harvesting and transporting the biomass fuel. In electricity generation bio-energy has a life-cycle emissions of 20 to 80g of CO_2 per kwh. This figure is far low when we compare the CO_2 generation of parallel operations. In fossil fuel run generators it is 955 g/kwh.

The biogas system basically comprises of the collection and processing of cattle dung, production and delivery of biogas and handling and application of the digested slurry in agricultural fields. The production process involves the mixing of wet cattle dung with an equal quantity of water. It is then put in the biogas plant where it is retained for some time for digestion in the absence of air. The gas thus produced has around 55 to 75 percent methane which is inflammable. This is then collected and sent to the kitchen. When this gas is burnt in silk mantles, it serves as a source of light. It can also be used in dual-fuel engines for motive power and generation of electricity.

The following data shows the potential of biogas production in India.

Cattle production in India	:	2.37 million
Average dung obtained per animal per day	:	10 kg wet dung
Total availability of wet cow dung	:	575 million tones per annum
Production of gas through the biogas plants	:	22425 million cubic meter
Kerosene replacement level by gas	:	13,904 million litres per year

The animal resource of Tamil Nadu is presented below:

Total number of cattles	:	93,53,141
Buffaloes	:	31,28,256
Sheep	:	58,80,788
Goats	:	59,19,713
Pigs	:	6,60,676
Horses and Ponies	:	6,003
Mules	:	78
Donkeys	:	50,606
Dogs	:	13,66,950

The dung production potential of various animals are furnished below:

Cow	:	10 kg/d/animal
Buffaloe	:	15 kg/d ,,
Bullock	:	12.0 kg/d ,,
Camel	:	6.0 kg/d ,,
Horse	:	10.0 kg/d ,,
Pig	:	2.25 kg/d ,,
Chicken	:	0.18 kg/d ,,

The energy intensity yield of various live system is shown below:

Human muscle Power	:	0.000837 GJ/J
Bullock	:	0.002646 ,,
Dung cake	:	2.1 ,,
Farm yard manure	:	0.668549 ,,
Biogas	:	0.0006 GJ/m^3

3. Biomass gasification

Biomass is an organic matter produced by terrestrial and aquatic plants and their derivatives. It includes forest crops and residues, crops grown especially for their energy content on "energy farms" and animal manure. Unlike coal, oil and natural gas which takes millions of years to form, biomass can be considered as a an immediate renewable energy source because plant life renews and adds to itself every year. It can also be considered as a form of solar energy as the latter is used indirectly to grow these plants by photosynthesis. Gasification process is one of the destructive path of generating energy from biomass.

Gasification may be defined as a process of converting a solid or liquid into a gaseous fuel without leaving any solid carbonaceous residue.

Gasifier is a chemical reactor which can gasify a variety of biomass such as wood waste, agricultural waste like stalks and roots of various crops, maize cobs etc.

Biomass gets dried, heated, pyrolysed, partially oxidized and reduced as it flows through gasifier.

The gas produced from a gasifier is a clean burning fuel having a heating value of about 950-1200 kcal/m^3. Hydrogen (18-20 percent) and (carbon-monoxide 18-24 percent) are the main constituents of the gas. There are two methods of converting biomass into useful forms of energy. They are biochemical and thermo chemical gasification.

Biochemical method is a low energy process and it entirely depends upon the action of bacteria which degrade complex molecule of biomass into simpler ones.

In thermo chemical method, biomass is processed at a high temperature. Depending upon the oxygen supplied, processes like pyrolysis, combustion and gasification occur. Under specific conditions of temperature and oxygen supply, a gaseous mixture rich in carbon-monoxide and hydrogen called as producer gas is formed.

Wood is charged at the top of the reactor and ash is discharged from the bottom. Air and steam are charged near the base of the reactor. The sequence of reactions occurring in a wood gasification process is

Drying	:	100 – 200^oC
Moist wood and heat	$\longrightarrow$	Dry wood and H_2O vapour
Pyrolysis	:	200 – 500 ^oC
Dry wood and heat	$\longrightarrow$	Char+CO+CO_2 +H_2 +CH_4 + tar and pyroligneous acids
Gasification	=	500 ^oC
Char + O_2 + H_2O	$\longrightarrow$	CO + H_2 + CO_2

The raw gas typically contains hydrogen 18 percent, CO 22.8 percent, CO_2 9.2 percent methane 2.5 percent other hydrocarbons 0.9 percent, oxygen 0.5 percent and nitrogen 45.8 percent.

Gasifiers are classified as per the direction of the gas flow and also according to the output or capacity of the gasifier.

The gasification technology has a tremendous field potential in terms of its applications as the process outputs can be converted into electrical, mechanical or heat energy.

Small size gasifiers (upto 10 kw) find applications in rural areas, especially for providing shaft line power to agricultural pumps, processing machinery and agricultural processing machineries like threshers, straw choppers etc.

Medium size gasifiers (10 – 50 kw) can easily meet the shaft line power requirements of various rural industries like saw mills, carpentary workshops, mechanical fabrication shop as well as small rice mills. They can also find its applications as a decentralized source of electrical energy in milk chilling centers, primary health coverage centers and for rural electrification.

Large size gasifiers (50 kw and above) can be used in rural as well as urban industries, besides being a source of energy to units like dairy, oil mill, mineral processing, brick manufacturing, ceramics and pottary industries etc. These can also be used in mining operations; forest based processing units, well drilling etc. These gasifier can also be used for total electrification of small and medium size villages. However gasifier application suffer from the following aspects

1. Fuel and supply cost
2. Capital costs and economics
3. Technology development
4. Safety
5. Market barriers.

4. Biogas

When organic matter undergoes changes (process of chemical change in organic matter brought about by living organisms) through anaerobic digestion, gas is generated. This gas is known as biogas. Biogas consists of 60-65 percent methane, 30-40 percent carbon di-oxide and traces of hydrogen sulphide, ammonia and other impurities. It is an explosive and toxic gas. Methane which is the principal constituent of biogas is colourless, odourless and tasteless.

Methane is also combustible at a concentration of 5-15 percent in air and therefore potentially hazardous. Tests using biogas as exclusive fuel in a petrol engine showed that energy present in 200 ft^3 (5.7 m^3) of biogas is equal to energy present in 1

gallon of petrol. Calorific value of biogas ranges between 5000-7000 BTU'S per cubic foot (0.03 cubic meter).

Biogas is difficult to store, compress or liquify. Biogas unlike **L**iquefied **P**etroleum **G**as **(LPG)** cannot be converted to liquid state under normal temperature. It is best suited for such applications as cooking, lighting, grain-drying, refrigeration and operating stationary internal combustion engines.

Being a toxic and explosive gas, it should be handled with requisite caution and care. Biogas is produced by digestion, pyrolysis or hydrogasification. Digestion is a biological process that occurs in the absence of oxygen and in the presence of anaerobic organisms at ambient pressures and temperatures of 35-70^{o}C. The container in which this digestion takes place is known as the digester.

Biogas plants are mainly of

1. continuous and batch types (as per the process)
2. the dome and the drum types
3. different variations in the drum type.

Following organic matter rich feed stocks are found feasible for their use as input materials for biogas production.

The animal wastes used are:

Cattle dung, urine, goat and poultry droppings, slaughter house wastes, fish wastes, foetus wastes, leather and wood wastes, sericulture wastes, elephant dung, piggery wastes etc.

The human wastes used are:

Faeces, urine and other wastes emanating from human occupations.

Agricultural wastes are:

aquatic and terrestrial weeds crop residue, stubbles of crops, sugarcane trash, spoiled fodder, bagasse, tobacco wastes, oilcakes, fruit and vegetable processing wastes, press mud, cotton and textile wastes, spent coffee and tea wastes.

Waste of aquatic origin are:

Marine plants, twigs, algae, water hyacinth and water weeds.

Industrial wastes are: sugar factory, tannery, paper etc.

The following three marine plants (waste of aquatic origin) are considered promising for biomass production

1. Water hyacinth
2. Algae and
3. Ocean kelp

Factors affecting biodigestion or generation of gas are

1. pH or the hydrogen ion concentration
2. Temperature
3. Total solid content of the feed material
4. Loading rate
5. Seeding
6. Uniform feeding
7. Diameter to depth ratio
8. Carbon to nitrogen ratio
9. Nutrients
10. Mixing or stirring or agitation of the content of the digester
11. Retention time or rate of feeding
12. Type of feed stocks
13. Toxicity due to end product
14. Pressure
15. Acid accumulation inside the digester.

Biogas being a clean gaseous fuel can be used in different ways such as

1. a cooking and lighting fuel
2. fuel for internal combustion engines for operating irrigation pump sets
3. compressed natural gas (CNG) being used as a vehicle fuel in Newzealand and Itlay
4. production of electricity by coupling a dual-fuel engine to an asynchronous generator.

5. Alcohol

The concern for the environment is causing several changes in our habits. For the past 30 years or so, environmentalist are expressing concern on the use of fossil fuels

such as gasoline. Gasoline is the most popular fuel in the world, and a gigantic percentage of the population of motor vehicles runs on gasoline, or other kind of petroleum-based fuel. The emissions of those vehicles are the main cause for this concern, because of global warming, and greenhouse effect.

Of course we could never stop using automobiles. They are the most practical way of locomotion man has ever created. It is meaningless to have a zero-emission car when a electrical power plant that generates power for charging the car's batteries is dumping tons and tons of smog or nuclear wasted in the atmosphere. Hydroelectric plants can't be set up any where. Hydrogen powered cars are too dangerous to be used on a large basis.

Since 1925, the Brazilian people came to know about the possibility of using alcohol as a fuel for automobiles. During those time, however, gasoline was abundant, cheap, and was still consumed in a small scale in Brazil, which retarded interest on perfecting the research that would lead to a better usage and exploiting of alcohol as a fuel.

As early as 1920, some cars were run on a combination of 75 percent alcohol and 25 percent ether. During the Second World War, alcohol helped to live with the gas shortage. It was combined with regular gas or used solely in engines converted for this purpose.

During the sixties, the Middle East became the biggest oil exporters in the world. The main production area was Saudi-Arabia, Iran, Kuwait and Iraq. Petroleum was the major source of power in the world and it's strategic importance was clearly noted during the oil embargo in the seventies. The oil crisis of the year 1973-74 and 1979-80 expressed themselves by considerable raise in the price of the oil barrel. Oil control is monopolized and the production growth also stagnated. This stagnation occurred simultaneously with a worldwide economic recession coupled with set back to oil-importing country's economy.

All the above reasons such as political, economic, social and ecological caused the world to look for a new source of power. Along with the resuming of investments on the search for petroleum in Brazilian territory, the Brazilian Government launched the National Alcohol Program, the PROALCOHOL (Proalcohol), with the goal of substituting the gasoline used in internal-combustion engines with ethyl alcohol or ethanol, probably the most radical measure ever taken to hold back petroleum consumption.

Between 1977 and 1979, there was an expansion on the production of sugar cane, which was the crop selected for the production of alcohol in Brazil. The factors that determinated this choice were the largeness of the Brazilian territory, the climate, which favoured the cultivation of sugar cane, and the domination over the alcohol-production technology.

The use of biomass in alcohol manufacture is not a new discovery. In the 1930's and during the Second World War, many countries converted agricultural waste products to alcohol for use in automobiles, as 10-15 percent blends with gasoline. Traditionally, alcohol for industrial use is manufactured from molasses. Excess grapes or other fruits, potatoes, starchy roots like cassava, mahua flowers and palm juice are being extensively used as a raw material to produce alcohol.

Ethanol and methanol are two alcohols commonly considered for fuel use. Ethanol (ethyl, grain alcohol) is produced by yeast fermentation of hexose sugar, derived from cereal grains, sugarcane or sugarbeet. Subsequent distillation process yields a product containing upto 95 percent alcohol. Additional treatments give completely water-free ethanol. Methanol is produced from cellulose products such as wood or crop residues. Methanol is commercially produced from natural gas. The nature of the emissions generated by alcohol is less.

Alcohol being a vegetable fuel, the auxiliary chemicals it produces are mostly ecofriendly.

If alcohol is solely used as a fuel worldwide, there will be enormous drop in the pollution levels in the near future.

Upto 20 percent of ethanol can be used with gasoline without any engine modification. For blending, the ethanol must be anhydrous, otherwise, a water-containing layer may exist in the mixture, causing erratic engine performance. The 95 percent ethanol can be directly used in modified engines. Methanol can be used at level upto 15 percent with gasoline and 100 percent in modified engine.

Alcohol fuels cannot be directly used in diesel engines because they do not readily combust in the diesel system. The alcohol must either be mixed with relatively expensive substances (amyl nitrate) to promote combustion or aspirated into the diesel fuel through a special device in the air intake.

6. Petroleum

Petroleum as "rock oil" was discovered near Titusville, Pennsylvania, in 1859, by a man drilling for water. This petroleum today has become the world's foremost source of energy, and the backbone of our industrial society. This petroleum is being collected in a crude form referred to as oil. Oil accounts for 38 percent of energy use worldwide. Oil's liquid form, high energy density, and relatively clean burning nature make it the most versatile of all fuels. When oil was first discovered, it was primarily used in the form of kerosene for lamps and stoves. Since that time, inventors have developed hundreds of new uses for oil, with the most prominent being its use in the internal combustion engine.

Oil was plentiful and cheap throughout most of the twentieth century, resulting its extensive use in transportation. Oil was also extensively used for generating electricity. Since oil was very cheap during those days it was not used very efficiently.

Crude oil, also called petroleum, is a complex mixture of carbon and hydrogen (hydrocarbons), also exists as a liquid in the earth's crust. On an average, crude oil is made up of 83 percent carbon (C) and 12 percent hydrogen (H), with the remainder being sulfur, oxygen and nitrogen. Crude oil found in different locations is never exactly the same. Some crude oil is black, thick and tar like, while other crude oils are lighter in colour, thinner and more volatile. The carbon and hydrogen in crude oil are thought to have originated from the remains of microscopic marine organisms that were deposited at the bottom of the seas and oceans. After having been buried under huge layers of other sediments, the organic material is transformed at high temperature and pressure into crude oil and natural gas. The oil and gas are then squeezed out of the marine sediments in which they were deposited, and make their way into porous sedimentary rocks such as sandstones and limestones.

This oil and gas migrates upward through the porous rock, as it is less dense than the water which fills the pores. Unless it reaches an impermeable layer of rock, the hydrocarbons will make their way to the surface and evaporate. For oil and gas to be trapped in quantities large enough to allow humans to recover them, these migrating hydrocarbons must reach a layer of impermeable rock through which they can't move. Crude oil is "mined" by drilling a hole on the reservoir rock (sandstone, limestone etc.). Often, the oil is under pressure and will come out of the hole on its own. In some cases, pumps and other more complicated procedures are required to recover crude oil from the depth.

Once crude oil is extracted from the ground, it is "refined" into many different products. Refining separates the "lighter" components of the crude oil, such as gasoline, from the "heavier" components such as fuel oil and lubricants. About 15 percent of crude oil goes into non-energy products such as plastics and paints, while the rest is eventually used for combustion in one form or another. Crude oil is not distributed evenly around the world, with the vast majority of remaining reserves being found in the Middle East.

Oil and its derivatives are used for a multitude of different tasks. But worldwide over half of the crude oil used for energy is employed in the transportation sector . Prior to the invention of the internal combustion engine in 1876, mechanized transportation was provided by the steam engine. Steam engines using coal or wood as a fuel were used to power ships and trains. But the above fuels are large volume and cumbersome for use in smaller applications. The gasoline powered internal combustion engine was able to deliver much more power from a compact design, making it an ideal match for many types of vehicles, including the automobile and later the airplane. At the present time, oil provides the energy for over 95 percent of the world's transportation needs.

When oil was cheap, it was often used to generate electricity, especially in remote locations such as islands which did not have access to hydroelectric power or coal. Oil was well suited for electricity generation because it is easy to transport and store. Today, oil is still used to generate electricity in many of these places, simply because the power

generation units are already sited. Since the "oil-crisis" of 1973, oil has been an increasingly expensive fuel for generating electricity.

The final major use of oil is for space heating in residential and commercial buildings. After coal was found to beinconvenient and before natural gas was widely available, oil was a very common fuel for heating homes.

The use of oil has two distinct types of environmental impacts. The first impact is felt during oil production, while the second is felt at the point of end use. Exploration works for oil, and transportation of oil have negative impacts on the environment. Ecosystems in areas of oil exploration and production are often damaged by the heavy equipment required for the job.

The transportation of oil from the recovery site to the end user can also damage the environment. Most of us are familiar with oil tanker spills such as the Torrey Canyon and the Exxon Valdez, which have shown the world what kind of damage may be caused to marine life by oil spills. Pipelines which carry oil to either shipping terminals or refineries can also disrupt ecosystems. The effects of the Alaska Pipeline, which crosses the permafrost in Alaska were not known when it was built, and are still poorly understood.

The final environmental impact related to the production of oil is indirect, and related to the important role the oil plays in the world economy. It is an undeniable fact that one of the reasons for the tension in the Middle East is the value of the oil reserves in that region. Many people believe that one of the main motivations behind the "gulf War" in 1991 was the world's need for reliable and inexpensive sources of oil. The Gulf war resulted in damage to the marine environment of the Persian Gulf, atmospheric pollution from burning oil wells, and damage to desert ecosystems by tanks and other heavy equipment.

The combustion of oil releases carbon dioxide (CO_2), which is a greenhouse gas responsible for global warming, as well as sulfur dioxide (SO_2) and nitrous oxides NO_x), which result in acid rain. Currently, oil directly used in automobiles is responsible for about 25 percent of the world's CO_2 emissions.

Use of oil is responsible for about 40 percent of CO_2 emissions. Similarly, the burning of oil products in vehicles and other applications is one of the largest sources of No_x, which cause acid rain. Finally, the incomplete combustion of oil, especially in transportation sector, results in increased levels of carbon monoxide (CO), unburnt hydrocarbons and ultimately ground level ozone.

7. Fire wood

Fire wood is an easy fuel available closer to our home. They are cut, split and stored explicitly for the purpose of burning to get heat.

Fire wood is divided into hard and soft woods. Hard woods such as oak are more dense than their softwood counterparts and consequently burn slower and produce more

heat. Good fire wood burns at a high temperature to eliminate as many air pollutants as possible and remains burning consistently.

The burning rate of any fire is really a consequence of the air flow. The greater the air flowing into and out of the wood stove or fireplace, the faster the burn rate of fire. The burn rate is regulated by adjusting the air flow with whatever gadget the wood stove or fireplace provides. Most of the air flow into the fire should come at the beginning of the process, adjusting for less air flow as the fire progresses. When the wood begins to burn down to a hot charcoal texture, it's time to add another log.

Finally, dryness is perhaps the golden rule of fire wood. Properly seasoned fire wood has less moisture content. Wood with a high moisture content burns irregularly. Some times it does not burn at all. If there's fire, there's no smoke.

8. Thermal energy

The development of power in any country depends upon the available resources in that country. The hydel power totally depends upon the natural sites available and also the hydrological cycle in that country. New sites cannot be humanly created for hydel power plants. The development of nuclear power in a country requires advanced technological developments and fuel resources. This source of power generation is not much desirable for the developing countries as it is dependent on high technology and high capital investment.

Many a times, hydel power suffer due to draught. Droughts occurrence completely hault's the nations progress. The calamity of rain or draught on power industry has been experienced by many states in the country. To overcome this difficulty it is absolutely necessary to develop thermal power plants in the country which are very much suitable to meet local needs.

The general layout of the thermal power plant consists of mainly 4 circuits. They are:

1. coal and ash circuit
2. air and gas circuit
3. feed water and steam flow circuit
4. cooling water circuit.

A thermal power station using steam as working fluid works basically on the Rankine cycle. Steam is generated in a boiler, expanded in the prime mover and condensed in condenser and fed into the boiler again.

1. Coal and ash circuit

In this circuit, the coal from the storage is fed to the boiler through coal handling equipment for the generation of steam. Ash produced due to the combustion of coal is removed to ash storage through ash handling system.

2. Air and gas circuit

Air is supplied to the combustion chamber of the boiler either through forced draft or induced fraft fan or by using both. The dust from the air is removed before supplying to the combustion chamber. The exhaust gases carrying sufficient quantity of heat and ash are passed through the air heater where the exhaust heat of the gases is given to the air and then it is passed through the dust collection where most of the dust is removed before exhausting the gases to the atmosphere through chimney.

3. Feed water and steam circuit

The steam generated in the boiler is fed to the steam prime mover to develop the power. The steam coming out of the prime mover is condensed in the condenser and then fed to the boiler with the help of a pump. The condensate is heated in the feed heaters using the steam tapped from different points of the turbine. The feed heaters may be of mixed type or indirect heating type.

4. Cooling water circuit

The quantity of cooling water required to condense the steam is considerably large and it is taken from lake or river or sea. The cooling water is taken from the upper side of the river It is passed through the condenser and resultant hot water is discharged to the lower side of the river. Such system of cooling water supply is possible if adequate cooling water is available throughout the year. This system is known as open system. When the cooling water discharging from the condenser is cooled again and supplied to the condenser then the system is known as closed system. Open system is economical than the closed system.

The different types of systems and components which are used in thermal power plants are listed below

1. Coal handling system
2. Ash and dust handling system
3. Draught
4. High pressure boiler
5. Prime mover
6. Condensers and cooling towers
7. Feed water purification plant
8. Different components used as economizer, super heater, feed heater etc

to increase the thermal efficiency of the plant.

Steam is generated in the boiler of the thermal power plant using the heat of the fuel burned in the combustion chamber. The steam generated is passed through steam turbine where part of its thermal energy is converted into mechanical energy which is further used for generating electric power. The steam coming out of the steam turbine is condensed in the condenser and the condensate is supplied back to the boiler with the help of the feed pump and the cycle is repeated.

The function of the boiler is to generate the steam. The function of the condenser is to condense the steam at a low pressure. The function of the pump is to raise the pressure of the condensate from the condenser to the boiler. The other component like economizer, superheater and steam feed heater are used in the primary circuit to increase the overall efficiency of the thermal power plant.

9. Hydrodynamic energy

Eighty percent of total electricity produced in the world, is hydel while remaining 20 percent is produced from nuclear, thermal, solar, geothermal energy and from magneto hydro dynamics (MHD) generators.

MHD power generation is a new development in electric power generation which is said to have high efficiency and low pollution. In advanced countries MHD generators are widely being used but in developing countries like India it is still under construction. This construction work is in progress at Trichy in Tamil Nadu under joint efforts of BARC, BHEL, Associated Cement Corporation and Russian Technologies. The principle of MHD generation is that when an electric conductor moves across a magnetic field, a voltage is induced in it which produces an electric current. In MHD generator, instead of solid conductor by a gaseous conductor, is used . If such a gas is passed at a high velocity through a powerful magnetic field, a current is generated which can be extracted by placing electrodes in a suitable position in the stream.

As its name implies, magneto hydro dynamics is concerned with the flow of a conducting fluid in the presence of magnetic and electric field. The fluid may be a gas at an elevated temperature or a light metal like sodium or potassium. An MHD generator is a device for converting heat energy of a fuel directly into electrical energy without a conventional electric generator. In this system, heat taken up at a higher temperature is partly converted into useful work and the remainder is rejected at a lower temperature. Like all heat engines, the thermal efficiency of an MHD converter is increased by supplying the heat at the highest practical temperature and rejecting it at the lowest practical temperature. The MHD generation with economic and physical factors will lead to a design output of the order of 1000 MW.

10. Alternate proteins

Proteins, carbohydrates, fats, minerals, vitamins, fiber and water are the basic components of a food. The human body cannot manufacture amino acids by its own. They have to be supplied in through diet. Food that contains balanced amino acids such as meat, poultry, fish, eggs, dairy supply complete proteins. Vegetables, seeds, grains, nuts provide incomplete proteins and must be combined carefully in a vegetarian diet.

Too little protein leads to fatigue, low antibody production, slow wound heating and liver problems.Too much proteins make extra fat tissue.The meal that remains after the oil has been extracted from soyabeans, peanuts and cotton seeds contains 40 to 50 percent protein. This meal is perhaps the world's cheapest source of aboundant protein. Certain artificial food mixtures have been synthesized using the materials such as incaparina, CSM, pro-nutro, fortifex and multipurpose food (MPF).

Incaparina, is a mixture of corn and cotton seed protein promoted by , the institute of Nutrition for Central America and Panama (INCAP). Another food mixture is CSM, composed of 25 percent soya bean, 70 percent gelatinized corn and 5 percent nonfat dry skim milk. Bal Ahar which is an Indian variant, made up of 70 percent wheat and 30 percent peanut protein concentrate fortified with lysine.

The development of these products gives hope to the prospect of the countries burdened with large populations and shortages of foods especially protein.

11. Non conventional food resources

Renewable resources are those that can be restored and replenished by nature in a reasonable amount of time.

All products are made from the resources of the earth. To maintain a sustainable supply, the resource must have the ability to renew itself. With the right sustainable use – the resource regain the expenditure in it's own way. Renewable resources naturally replenish themselves and can last as long as the earth exist.

Of course, all the resources of the earth are constantly being made by nature. There is difference in period of regaining the loss. The time differs for a micro-organism to reproduce, a fish to be born, a tree to grow, and crude oil to form. Ideally, we should use all resources at the rate at which they can be replenished by nature.

Renewable resources include all plants, animals, surface water, soil and sunshine. Certain basic minerals (such as salt or clay or the silica used to make glass) are also sometimes considered renewable because they are among the basic building blocks of nature and are extremely abundant.

If a product is made from a renewable resource it is required to look for some indicator of sustainable practices. Substainable food products are organically grown, recycled, or sustainably harvested. Agriculture, for example, is sustainable when the fertility of the soil is maintained, so that crops can continually be planted and harvested without depleting the vitality of the field. By contrast, agricultural methods that employ toxic pesticides and artificial fertilizers destroy topsoil and eventually make it impossible to use the land for growing crops. Even though food plants are a renewable resource, poor farming practices can reduce or even eliminate supply.

12. Food security

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.

Key components of food security are

1. Production or availability of nutritionally adequate and safe food
2. Access or capacity to acquire nutritionally adequate and safe food.

The world produces enough food to feed everyone. However, there are countries, regions within countries, villages within regions, households within villages and individuals within households which are not able to meet their food needs. Food security requires an available and reliable food supply at all times. Individuals and households must have access to sufficient, safe and nutritious food both in quantity and quality to meet their daily dietary requirements for a healthy and productive life.

Food security has become an issue of increasing public concern. With the recession of the 1980's the demand for food assistance rose dramatically and a massive charitable food assistance system emerged. The first Food Bank in Canada was established in 1981 in Edmonton, Alberta. Although limited data on the use of charitable food assistance programs exist, there is ample evidence that the number of Food Banks, collective kitchens, school-based breakfast or community-based feeding programs geared to the needy has risen sharply.

The Canadian Association of Food Banks estimates that 2.4 million Canadians suffer from hunger. There is strong evidence of food-related health and nutritional problems in Canada, particularly in children, the aboriginal community, single mothers and the elderly. For aboriginals, contaminants in water and traditional food supplies are matters of great concern. Consumer awareness and concern for food quality and safety including biotechnology, genetic engineering, chemical fertilizers and pesticides are being increased nowadays.

Vulnerable groups include: single parent women, children, elderly people, aboriginals, homeless persons, unemployed people, refugees and new immigrants.

Non-governmental organizations (NGOs) and local administration, with support from federal and provincial governments help, provide access to food and other supports needed to vulnerable persons.

Food and Agriculture Organization, and the international community made the commitment to reduce by half the number of hungry and undernourished not later than are 2015.

Question Pattern

Marks : 1OO

SECTION - A (5×5=25 Marks)

Answer any FIVE out of EIGHT.

SECTION - B (5×15 = 75 Marks)

Answer any FIVE out of EIGHT.