Chapter 6

BIOSPHERE

6.1 Sustainable and Non-sustainable use of Biological Populations

Biodiversity plays an important role in providing food and medicine, besides energy and clothing. A total of about 3,000 plant species are used worldwide as a food source, with only 200 of these being domesticated. However, just 20 of these plants provide more than 80 per cent of our food at the present time. A smaller number of animal species and their produces are used by humans as food. However, the scale at which this resource is utilised is often enormous. For example, in 1989 world landings of fish and other aquatic life forms totalled 99.5 mega-tonnes, 70 per cent of which was for human consumption.

Globally 3.5 billion people rely on plant-based medicine for primary health care, and in the USA 25 per cent of medicines prescribed are still based on compounds originally found in plants. Many industrial materials, such as fibres, resins, dyes, waxes, pesticides, lubricants and perfumes are derived from plant or animal sources. Trees provide more than 3.8 million cubic metres of wood annually for use as fuel, timber or pulp. Besides such consumptive use, there is now a rapidly

growing leisure industry, like ecotourism, which involves the non-consumptive "use" of the living world.

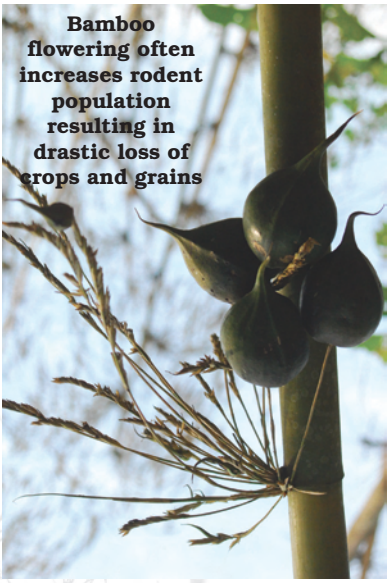
As a result, utilisation of bio-resources often exceeds nature's production capacity causing over harvest, resource depletion and yield reduction. Such non-sustainable use exceeding the "carrying capacity" leads to resource substitution by alternative species or regions.

Traditionally, humans tried to minimise bio-resource overuse by adopting certain cultural and religious practices, based on qualitative wisdom that appears quite logical such as:

- Earmarking of certain spaces prohibiting harvesting of plants and animal sources. For example "sacred" forests or water bodies, which served as shelter or breeding ground for many species.
- Practise of keeping the land fallow by shifting the harvest area such as grazing lands, after each season or year or few years, that permitted natural regeneration of the resource.
- Prohibiting harvest of certain species and also its consumption in certain seasons such as avoiding fishing during the monsoon, so that species could breed and grow and avoid loss of human life while fishing during the rough sea.
- Use of non-damaging or less-destructive methods such as not permitting metal tools for harvest or harvesting only few tubers from a plant, facilitating its re-growth.
- Fixing certain harvest quota such as number of animals for a given forest area.
- Quality norms such as harvest of only the mature fruits, which prevents collection of immature or over-mature fruits at the single mass collection event. These unharvested resources are useful to the wildlife or for regeneration.

Modern methods of sustainable use include establishment of extractive reserves for timber, hunting reserves for animals, hunting permits for certain number of kills etc. Several countries have drawn up Biodiversity Strategy and Action Plans (BSAP) and have enacted legislations to ensure sustainable use of their bioresources. Global Environment Facility (GEF) of the United Nations Environment Programme (UNEP) is promoting model projects in this sector.

6.2 Sustainable Agriculture



Bamboo flowering often increases rodent population resulting in drastic loss of crops and grains

Sustainability is based on the principle that we must meet the needs of the present without affecting the ability of future generations to meet their own needs. Sustainable agriculture is the one, which is ecologically sound, yet has economic profitability and imparts social and economic equity.

Green Revolution in India introduced High Yielding Varieties (HYVs) of agricultural crops by using improved seed variety which required the application of high doses of fertilizers. The farmers began growing only one crop at a time while before they were growing more than one crop along with native wheat varieties. Traditional crops of high nutritive value were also replaced. According to Central Rice Research Institute the HYVs are susceptible to major pest, with a crop loss of 30 to 100 per cent. High yield varieties gave a high yield only after application of chemicals in the form of fertilizers and pesticides. The excessive use of fertilisers in farms led to pollution of surface and ground water resources. Many chemicals present in fertilizers and pesticides entered the food chain causing severe damage to other fauna. There were severe pest problems to crops for which no effective solutions were available, yet people kept on using these chemicals just because subsidies were available. As a result of excessive use of chemicals the soil became acidic thereby severely affecting its fertility.

Elements of sustainable agriculture include practising proper soil management, selection of proper crop and crop rotation, proper irrigation, and judicious inputs of fertilizers and pesticides and their replacement with organic substitutes.

Soil management: Soil is the key component of sustainable agriculture. The fertile soil can reap good harvest for years to come. This is possible only when the soil retains its microfauna and humus. This can be achieved by use of biofertilizers and also practices like crop

rotation. Crops and seeds selection should be done keeping in view the quality of soil and climatic conditions of a place rather than using the same variety of seeds uniformly in all parts of the country. Hence, crops suited to that agro climatic zone should be selected for long-term soil fertility.

Diversity in crops: The stability of a biodiverse agriculture is perhaps the most important characteristic, as recorded from many parts of the world. This can be best illustrated by a once common practice of the Garhwal Himalaya, the *baranaja*—meaning "12 grains". This practice involved sowing of many crops in different parts of a single farm to obtain optimal and sustained yields. Since maturity periods of these crops varied, different crops were harvested at different times, that helped to retain soil moisture and provided a constant supply of food.

Soil fertility was recharged by growing leguminous plants like pulses. According to some assessments, practicing *baranaja* provide a higher overall productivity (apart from meeting diverse needs) than if the field was to be converted into a soyabean monoculture, which was being propagated by agricultural agencies in the region. The erosion of genetic diversity and the extinction of indigenous seed varieties is a major threat to food security.

Irrigation: Irrigation without making provision for drainage of excess water can lead to water logging. Water logging brings salts to the soil surface. This excessive salt in the soil is called salinisation. This leads to desertification of land which is a severe problem and needs to be avoided.

Crops like millets and oil seeds which were grown earlier required less water but shift in crops to sugarcane in many places required water inputs throughout the year. Also the hybrid crop varieties of rice and wheat introduced need much more water than the indigenous varieties. For example, high yielding varieties of wheat require three times more irrigation than the traditional varieties.

Inputs of fertilisers and bio-pesticides: Organic farming is said to be a more sustainable form of agriculture. Organic agriculture advocates avoiding the use of chemical fertilizers and pesticides and use of bio-fertilizers and bio-pesticides like *neem* oil etc.

Use of biotechnology: Increase in population needs to be supported with food security and biotechnology can help in achieving food security using genetic engineering for nutritional enhancement in a crop. This technology can

be used not only to develop new crop varieties which are tolerant to diseases, pests and abiotic stresses but also to improve productivity and nutritional quality of food. To achieve this the traditional crop varieties if conserved will be of immense value to Indian agriculture.

6.3 Impact of Genetically Modified Organisms

An introduction of a foreign (new) biotic (living) or abiotic (non-living) factor in a natural environment tends to impact the existing ecosystem. Every ecosystem has various biological components with the knowledge to bring out biochemical processes stored in their genome. Hence, the total productivity of an ecosystem is decided by mutual interaction of these biological components or in other words their genomes. An ecosystem at genome the level can be defined as a natural unit where the genomes of plants, animals and micro-organisms in that area function together and carry out all the bio-geochemical process.

It is imperative therefore, if a genetically modified (GM) biological unit is introduced in an ecosystem, it is expected that it is going to affect the ecosystem. However, the impact will always not necessarily be negative. GM tomatoes or other GM products appeared on British and US supermarkets around 1994-96. Around the same time, the Swiss voted overwhelmingly against a ban on research of genetic modification of plants and animals, whereas the European Commission decided on the labelling of genetically modified food. This suggests that there was a mix response from international community towards the GM products and even today it prevails.

GMO: Definition

In biological systems, a change in the inherited traits of a population from one generation to the next is defined as evolution. It happens over a period of time. One of the ways of evolution could be gene flow; it is the exchange of genes between populations, which are usually of the same species. Horizontal gene transfer is one such process, which involves the transfer of genetic material from one organism to another organism that is not its offspring. This is most common among bacteria. This is the main reason for development of antibiotic resistance in bacteria. This process of gene transfer leads to a

modified organism where the modifications are decided by the rules of nature. A genetically modified organism (GMO) or genetically engineered organism (GEO) on the other hand is an organism whose genetic material has been altered using genetic engineering techniques. These techniques are generally known as recombinant DNA technology. With recombinant DNA technology, DNA molecules from different sources are combined *in vitro* into one molecule to create a new gene. This reared DNA is then transferred into an organism and is responsible for the expression of modified or novel traits.

GMO: Micro-organisms

Genetically engineered micro-organisms could be the main factor that would induce the medical revolution of tomorrow. Micro-organisms can be genetically altered to synthesise human protein that could be the cure for a large number of diseases, if the right dose can be administered at the right place at the right time. Researchers in Belgium and the Netherlands are poised for the first trials in humans. If the tests get the go-ahead, it will be the first step towards a radically new kind of therapy: using GM bacteria to deliver therapeutics.

GMO: Plants

Genetically engineered plants represent a hope that could wipe out famine, reduce environmental pollution caused by pesticides or developing new varieties of plants. A strain of rice fortified with iron could give a new lease of life to some 2 billion rice-eaters worldwide who suffer from anemia. Another example of GMO plant is cotton engineered with a toxin-producing gene from *Bacillus thuringiensis* (Bt) which works as a protectant against pests in the field. Similarly, various vegetable crops are also now engineered to provide protection against pests using Bt or different genetic determinates. Genetically engineered plants are being used to fight natural pests and will go a long way in preventing famine. They also would provide a respite from pesticide contaminated food and reduce the risk of pesticides polluting the environment.

GMO: Animals

Perhaps the most popular genetically engineered animal is Dolly, the cloned sheep. It not only represents the

progress made in cloning technology but also a means of understanding the animal system to fight against various diseases. Gene therapy and stem cell research are the solutions of tomorrow and experiments are already in practice using genetically engineered mice making them immune to diseases, for example, diabetes.

GMO: Products

The new generations of therapeutics are now emerging by directly or indirectly using the GMO approach, for example insulin molecule is now being produced at commercial level by using GMO technique. Despite the advantages of genetic engineering, there is still a hot debate on the release and use of GMOs. Two main points of concern are the use and release of antibiotic resistant marker genes, and the ethical issue of whether research in this direction should be allowed or not, since it tampers with the natural laws.

GMO: Regulatory Agencies

A number of regulatory agencies have been initiated in each country to look into dealings with genetically modified organisms. These agencies are designed to protect the health and safety of people, and to protect the environment, by identifying risks posed by or as a result of gene technology, and by managing those risks through regulating certain dealings with GMOs. In India, the Review Committee on Genetic Manipulation, under the aegis of the Department of Biotechnology, Ministry of Science and Technology, reviews all issues related with GMOs and a panel of experts discuss all facets before recommending the use of GMOs.

GMO Future

Recently, in December 2007, there were two patent applications published by scientists at the J. Craig Venter Institute. It includes methodology for preparation of synthetic genomes and for transferring whole or partial genomes into natural or artificial cells. This could be the beginning of a new era of synthetic biology – an emerging field where the biological functional units will be constructed in part from chemically synthesised DNA.

6.4 Deforestation, Over-grazing, Over-fishing

An intrinsic threat to ecosystem and biodiversity is overuse of its resources. This includes deforestation due to land-use change or over-harvest of forest produce, over-grazing and over-fishing in the aquatic context.

Deforestation

Various natural and human processes convert forest areas into non-forest areas. A report from the World Commission on Forests and Sustainable Development suggests that the forests of the world have been exploited to the point of crisis and that major changes in global forest management strategies would be needed to avoid the devastation.

All types of forests are under great pressure. The rate at which deforestation is increasing, is highly alarming. The loss of rainforests around the world is most unfortunate, as these are rich in biodiversity. Traditional knowledge about forest produce, agro-forestry, medicinal values, industrial applications and evolutionary information is quite rich. Brazil with estimated 55,000 species of plants, amounting to approximately 20 per cent of the world's total and India for example, which has about 46,000 plants and 81,000 animal species (around 8 per cent of the world's biodiversity) are two typical examples where forests are under great threat. For example, Forest of Western Ghats in India has lost 40 per cent of forest area between 1920-1990.

The major pressures leading to deforestation include:

- Encroachments of forestlands for agriculture and ranching (vast areas for rearing of animals and agriculture).
- Development projects such as reservoirs, roads, industry etc.
- Over-harvest of timber, fuel wood, severely degrade vast forest areas.
- Over-grazing, fire and other pressures like encroachment for human settlements.

Deforestation for Jhum cultivation

Deforestation has the following adverse impacts on the ecosystem and society:

- Loss of biodiversity.
- Reduction of carbon absorption capacity and consequently lowering oxygen emissions due to photosynthesis.
- Reduction of forest produces such as fuel wood, timber, resins, medicines, food etc.
- Increase in the rate of landslide, soil erosion, floods, changes in rainfall patterns etc.

Though India faces deforestation at the rate of 2-3 per cent of its forest area per annum for a few decades in the past, massive afforestation and Joint Forest Management (JFM) scheme have neutralised its effect to some extent, and the forest area is now stabilised at 22 per cent of the country's land area.

Over-grazing

It is a process wherein grazing occurs in a specific area beyond its carrying capacity leading to degradations of the areas. Over-grazing causes vegetation degradation in the form of poor basal cover, low plant density and changes in plant species.

The pressure of grazing on forests has greatly increased, because of rise in livestock numbers, as well as pasture lands have been taken over for various purposes including irrigated cultivation, plantations, and urbanisation.

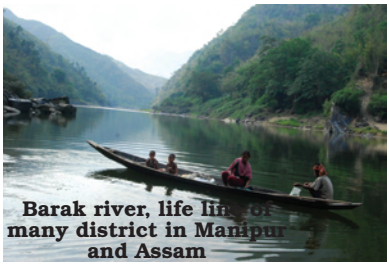
Reduction of habitats due to various reasons leads to over-grazing of remaining parts. For example, reduced Lasiurus grasslands in Rajasthan are now being degraded by over-grazing and waterlogging and land-use changes caused by the Indira Gandhi Canal. Various grassland species like the Great Indian Bustard and Lesser Florican are endangered due to various pressures on their habitat, of which over-grazing is one of the main reasons.

Over-fishing

Fishing is a day-to-day activity of the fishermen to earn their livelihood. The fishermen fish in the lotic (running) and lentic (stagnant) water bodies with diverse types of fishing gears and methods. Specific gears are used for specific fish type, fishermen type and season.

Over-fishing is excess harvesting of fish against its productive population. Sometimes the fishermen go

for over-fishing due to: increase in demand, less availability of fish vis-à-vis number of fishermen, materialistic nature of fishermen, changes in fishing techniques (use of fishing trawlers), expansion of fishing areas (deep sea fishing), not recognising traditional norms like ban in monsoon period on fishing in some parts of the world etc. Whatever be the cause, over-fishing is not encouraged for the welfare of the fish, the water body and fish consumers.


Barak river, life line for many district in Manipur and Assam

The global fishing fleet is currently 2.5 times larger than what the oceans can sustainably support — meaning that humans are taking far more fish out of the ocean than can be replaced by those remaining. As a result, 52 per cent of the world's fisheries are fully exploited, and 24 per cent are overexploited, depleted, or beyond the level of recovering from depletion.

Seven of the top ten marine fisheries are fully exploited or over-exploited. These amounts to about 30 per cent of all capture fisheries production. As many as 90 per cent of all the ocean's large fish have been eliminated. Several important commercial fish populations have declined to the point where their survival is threatened.

Unless the current situation improves, stocks of all species currently fished for food are predicted to collapse by 2048. Over-fishing cannot be curtailed unless the number of fishing vessels are regulated and the small mesh-sized fishing nets are not permitted.

In India, over-harvesting has begun to deplete the stock of many species of fish, especially on the west coast following the introduction of trawlers. Around 1970, the harvest was of the order of 50,000 tonnes per year. The current harvest is to the order of 2.5-3 million tonnes per year. This increase was facilitated by increased mechanisation of the craft, introduction of new gears and fish-locating devices and improvements in infrastructure for marketing the products inland and abroad. This is already at the maximum sustainable yield (MSY) for most fisheries and has in fact exceeded the MSY in some of the species, notably the shrimps, and in some of the coastal states, notably Kerala. The declining trend does not *per se* cause a loss of species, but there is a loss in their abundance.

6.5 Concept and Value of Biodiversity

The term biodiversity refers to the variety of life that exists on earth. The word biodiversity is an all encompassing one. It refers to all living forms that exist on earth, whether domesticated or wild. Hence, the term biodiversity includes everything from the smallest micro-organisms to the largest plants and animals; from creatures that swim to those that fly, walk, or are stationary. Biodiversity includes all species that live or evolve in different habitats and ecosystems such as: rainforests, grasslands, marshes, deserts and oceans, etc. It also refers to the diversity of genes found within a species, which would explain why for example, all mango trees do not look alike or all offspring of a dog are not identical.

There are many reasons why biodiversity is important to the environment. However, before taking an anthropocentric view of the value of biodiversity and seeing the different ways human beings depend on biodiversity, it is first important to acknowledge that all species have a right to exist on earth, a right just as much as all human beings do. Each and every living form has a role to play in the very fine balances that exist in nature, and it would be ethically wrong to value species only from the standpoint of human welfare.

The fact that all human beings depend on biodiversity either directly or indirectly in many ways is becoming increasingly clear to us. Many people all over the world depend on bio-resources to satisfy their immediate needs of food, shelter, medicine, clothing, fodder and fuel. In India, about 70 per cent of our population meets its basic needs directly from local ecosystems.

Human health is closely linked to biodiversity. About 80 per cent of the world's population uses medicines that are derived from plants and animals. More than 25 per cent of the prescription drugs that are used in the world contain compounds that are derived from the natural world. There is also a growing realisation that being close to natural surroundings promotes one's state of health.

Biodiversity is closely linked with cultural, spiritual and religious practices and beliefs. Many species have been given a special religious significance. For example, felling or cutting of many trees has been prohibited in many communities, for example, the banyan tree. Similarly killing of some birds and animals considered

sacred is forbidden. Patches of forests, mountains, lakes etc., have been considered sacred by communities, who have then observed strict rules that have protected or conserved them.

The fact that biodiversity plays an important role in meeting our basic needs is easily visible to us. We, however, may not be so aware of the fact that biodiversity plays a crucial role benefitting the ecosystem like soil formation, decomposition, nutrient recycling, enhancement of air and water quality, flood control, maintenance and raising of the water table and many more. These ecosystem benefits keep the planet healthy and make it a liveable place for all species.

A nation's economy has a direct bearing with the extent of biodiversity that exists in the country. Some of these can be easily valued in economic terms if we consider the cost of the goods that biodiversity gives us in terms of agricultural crops, medicines, fibres for our clothes and so on. It is more difficult to assess in economic terms the role of biodiversity in providing ecosystem services. The value of services provided by ecosystems worldwide is estimated to be $33 trillion or approximately 1.32 lakh crore rupees per year, which far exceeds the value of human produced goods and services which is estimated to be $18 trillion or approximately 0.72 lakh crore rupees per year!

6.6 Components of Biodiversity – Genes, Species and Ecosystems

According to the Convention on Biological Diversity CBD (1992), biological diversity means the variety and variability among living organisms of a region, from all sources including *inter alia*, terrestrial, marine and other aquatic ecosystem, and the ecological complexes, of which they are part. This includes diversity at genetic and molecular levels, within and between species and among ecosystems. But, Gaston (1998) defined biodiversity as the sum total of life, physical expression and genetic potential contained in the array of the organism living today. It is the bank of the earth's successful genes: a bank that holds some 3.5 billion years of life's solution to the problem of surviving and competing in our planet (Kevin et al., 1998). Thus biodiversity has three components viz., genes, species and ecosystems.

Genetic diversity: It represents the heritable variations within and between organisms of a population. It refers to the total number of genetic characteristics expressed and recessed, in all of the individuals that comprised a particular species.

Species diversity: Species diversity refers to the variety of species in a site or habitat. A species is a group of organism (plants or animals) that are similar and able to produce viable offspring in their natural conditions. It presently includes between 15 to 40 million species on earth though scientists could classify only 1.75 million.

It has been found that species richness increases from higher latitude to lower latitude. The most popular way of measurement of species diversity is by calculating Shannon and Wiener Index (1949).

It is given by the formula:

$$H = \sum_{i=1} \left(\frac{Ni}{N} \right) \log \left(\frac{Ni}{N} \right)$$

Where: Ni = Total no. of individuals of a species.

N = Total no. of individuals of all the species in a site.

Ecosystem diversity: Ecosystem diversity includes the relative abundance of species, age structure of a population, the pattern of communities inside a habitat and change in community composition. Thus it is regarded as the variation of habitat of community types and abiotic environment in a given area. Therefore, an ecosystem may include a variety of habitats like forest, grassland, lakes, rivers, ocean, etc., interacting with each other and with the abiotic environment.

Diversity can be defined at three scales, viz.:

1. The diversity within a site or a habitat referred to as alpha (α) diversity. It is measured locally at a single site.
2. The differences between habitats referred to as beta (β) diversity. It measures the amount of change between 2 sites or habitats. It is usually expressed in terms of similarity index between communities, (or species turn over rate) and between different habitat in the same area.
3. The differences in site diversity over the large areas such as continent is referred to as gamma (γ) diversity.

Biodiversity on earth is a product of 3.5 billion years of evolution. Hence, it is the sacred duty of human kind to conserve it for our sustainable future.