UNIT 8 BIODIVERSITY

Structure

8.1 INTRODUCTION

The enormous variability in life forms and their associations is generally referred as **biodiversity**. Biological diversity or "bio-diversity" was first conceptualised by Edward O Wilson in 1988. The term biodiversity has gained popularity for the past one and half decade, especially since the declaration of Agenda 21 at the Earth Summit in Rio de Janeiro, Brazil, in 1992. In the Convention on Biological Diversity (CBD) at earth summit, all participating Governments agreed on an "Official" definition of biological diversity as:

"*The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."* Therefore, biodiversity is the variety of the life forms including their genetic make up and all kinds of their assemblages.

The biodiversity related to agriculture and which is fundamental to food and nutritional security, includes plant, animal, soil organism, insect and other flora and fauna in agro-ecosystems as well as elements of natural habitats that pertain to food production. It has multiple economic, ecological and social benefits and is a crucial component of sustainable agriculture.

In the earlier two units we had discussed the issues related to land and water management and their role in determining the food and nutritional security. A rapidly growing human population, with its need for more food, water, energy, space and other resources threatens the survival of our fellow species. In this unit we discuss the components of biodiversity and its importance in agriculture. We also explore the forces that threaten agro biodiversity and the various strategies for preserving it. We provide necessary information that would generate interest in conserving agro-biodiversity in a broader perspective for a sustainable form of development, which envisages the integration of economic, social and environmental goals. These goals coincide with the provisions of CBD and also underscore the importance of meeting interests and protecting the rights of the people.

Objectives

After studying this unit, you should be able to:

- explain the importance of biodiversity and the need for its conservation;
- suggest ways of protection of biodiversity rich areas;
- implement target incentive measures which have positive impacts on agro-biodiversity, in order to enhance sustainable agriculture;
- help empower indigenous and local people to build capacity for *in situ* conservation and sustainable use of agricultural biodiversity;
- encourage evaluation of impact on biodiversity from agricultural development projects;
- promote partnership among different stakeholders;
- promote research and development on integrated pest, soil and nutritional management for maintenance of biodiversity both at macro and micro level;
- encourage regulations or measures to encourage appropriate use of agrochemicals; and
- study impacts of various projects on agro-biodiversity and of intensification on ecosystem and biomass.

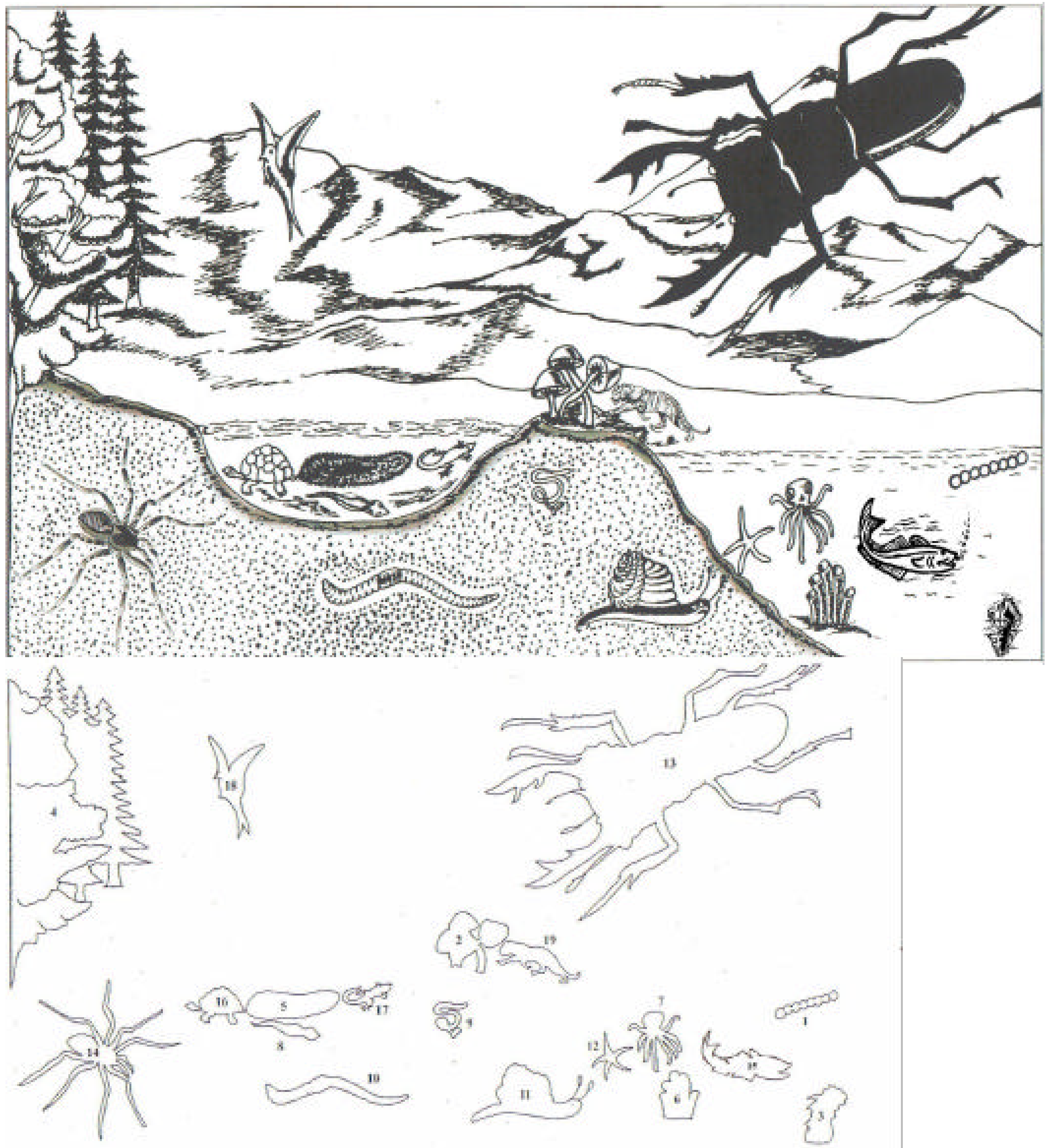
8.2 COMPONENTS OF BIODIVERSITY

The complexity of the diversity in life is manifested in variety of forms and functions of organism and their communities. Basically, this diversity of life is divided into three fundamental hierarchical categories that describe different living systems that can be measured in different ways. These categories are species, genetic and ecosystem diversity.

8.2.1 Species Diversity

Species diversity refers to an enormous number of individuals belonging to interacting groups or populations of distinct species or sub-species. It can be assessed in terms of species or the range of different types of species an area contains. The number of species in a region - its 'species richness' is often used as a measure of species diversity. A more precise measurement, 'taxonomic diversity', considers the relationships of species to each other. For example, an island with two species of birds and one species of frog has more taxonomic diversity than an island with three species of birds but no frogs (UNEP, 1995). Thus even though there may be more species of beetles on earth than all of the insects combined, they do not account for the greater part of the species diversity because they are so closely related.

Some estimates of biodiversity indicate the presence of 10-30 million species on the earth (Stork, 1993), of which 73 percent are bacteria, 18 percent flowering plants. Insects account for about 76 percent of all animals, and of all insects, about 60 percent are arthropods (Fig.8.1). Of the total species, 1,719,183 are described (UNEP Global Diversity Assessment, 1995) and of these 250,000 species belong to higher plants (14.5%). Of the 250,000 higher plant species only about 5,000 have been studied in detail.



Size of individual organisms represents number of described species in major taxon.
Unit Area : ☐ = approximately 1,000 described species.

Taxon

1. **Monera (Bacteria, Blue-green algae)**
2. **Fungi**
3. **Algae**
4. **Plantae (Multicellular Plants)**
5. **Protozoa**
6. **Porifera (Sponges)**
7. **Coelenterata (Jellyfish, Corals, Comb Jellies)**
8. **Platyhelminthes (Flatworms)**
9. **Nematoda (Roundworms)**
10. **Annelida (Earthworms etc.)**

Taxon

11. **Mollusca (Mollusks)**
12. **Echinodermata (Starfish etc.)**
13. **Insecta**
14. **Non-insect Arthropoda (Miltes, Spiders, Crustaceans etc.)**
15. **Pisces (Fish)**
16. **Amphibia (Amphibians)**
17. **Reptilia (Reptiles)**
18. **Aves (Birds)**
19. **Mammalia (Mammals)**

Fig.8.1: Number of species described in major taxonomic groups. (The size of the organism represents the number of species)

There has been a definite bias towards describing large organisms that are considered attractive or appealing (such as flowering plants or butterflies), closely resembling humans, and have a direct impact on human activities (pests for example). This has resulted in under-estimating the importance of micro-organisms including algae, bacteria, fungi, protozoa and viruses, which are vital to life on earth and to the existence of larger organisms dependent on the continued availability of the micro-organisms.

Agriculturally, approximately 7000 species of plants are consumed globally, of which 150 have entered world commerce and 103 account for 90 percent supply of human food and nutrition (Prescott-Allen and Prescott-Allen, 1992). Of these, three crop species - maize, wheat and rice give 60% of the calories and protein obtained from plant systems by human beings (Wilkes, 1983). For instance, India is 7th in number of domesticated plants and animals (Khoshoo, 1995). It has 334 wild relatives of crop species (Arora, 1991). Additionally, the native tribes use another 1,532 wild edible plant species. These include 145 species of roots and tubers, 521 of early vegetables/green, 101 of bulbs and flowers, 647 of fruits and 118 of seeds and nuts (Gautam and Singh, 1998). In addition, nearly 9,500 plant species of ethno-botanical uses have been reported from the country, of which around 7,500 are for ethno-medicinal purposes and 3,900 are multipurpose/edible species (Anonymous, 1998).

Box 8.1: India – A Megadiversity Center

India is considered one of the 12 "mega-diversity centres", housing an estimated 8 percent of the world biota described so far. It contains two of the 25 biodiversity "hotspots", the Western Ghats and Eastern Himalayas, with thousand of endemic flora and fauna. The Indian flora and fauna represent nearly 12 and 8 percent of the global floral and faunal diversity respectively. The floristically rich, India has about 141 endemic genera belonging to over 47 families of higher plants. As per Botanical Survey of India (BSI), India has 46,214 plants species (MoEF, 1998). Of these, about 17,500 (7,000 species in north east region alone) represent flowering plants (7% of the world flora); 37 % of them are endemic. Of the endemic species (4,950), the largest number (about 2532) of species are located in the Himalayas followed by peninsular region (1,788 species) and Andaman Nicobar Islands (185 species) (Paroda et. al., 1999). India is a treasure of wild economic plants, particularly wild edible and medicinal plant species, which are largely utilised locally in several *Ayruvedic* preparations. It also holds half of the world's aquatic floral diversity.

8.2.2 Genetic Diversity

Genetic diversity refers to the variation in terms of genetic make up within species, which is transferred across generations. The number of possible combinations of **genes** and of the molecules making up the genes is immense. Genetic variation occurs to varying degrees in most species of plants and animals. It could refer to the differences in genetic makeup among different populations of the same species (such as the thousands of traditional rice varieties in India) or to genetic variations among individuals within a population of a single species (which is high among Indian rhinos and very low among African cheetas). Individuals belonging to a species share, by definition, certain characteristics, but genetic variations determine the particular characteristics of individuals within the species. This variety of genetic material within species has enabled distinct species to evolve through natural selection. In general, species that inhabit large areas and interbreed throughout the whole area have a higher rate of gene flow and show few or no localised characteristics; however, species living in small isolated areas have low rates of **gene flow** and, as they adapt over time to their particular environment, they develop into distinct, localised populations. Genetic diversity measurements were applied mainly to domesticated species and populations held in zoos and gardens, but now are also being applied to wild species.

Gene is the functional unit of heredity; the part of the DNA molecule which codes for one polypeptide and so for some characteristic feature.

Gene flow is the physical movement of genes through the area where a population lives. In animals, genes flow when animals move around. Plants cannot do so but their seeds, gametes, pollen and spores can move. Thus pollination and seed dispersal both lead to movement of genes within a population.

In India around 583 crop plants are reported to be cultivated (Anonymous, 2000). This includes 168 species earlier reported under Hindustani centre, one of the eight **Vavilovian centres** (refer to Unit 1) of origin and diversity (Zeven and Zhukovsky, 1975). India is the centre of origin of several crop species like, rice and minor millet in cereals, pigeon pea in pulses, sugarcane in cash crops, bitter gourd, amaranths in vegetables, coconuts in plantations crops etc. In addition, the Chinese, Moguls, Arabs, Spaniards, Portuguese and British introduced many crops. The introduced **genotypes** were grown in diverse agro-climatic conditions, subjecting them to various climatic pressures, and natural and farmer's selection leading to establishment of diverse genotypes adapted to different agro-climatic conditions with diverse constellation of desirable genes. Hence, India became a centre of diversity for a large number of crops species like rice, wheat, barley, minor millets, pigeon pea, chickpea, mungbean, urdbean, horsegram, mothbean, ricebean, clusterbean, sesame, okra, eggplant, cucumber, melon, jute, cotton, several forage grasses, ginger, turmeric, pepper, cinnamon, cardamom, citrus, banana and plantains, jackfruit, mango, tamarind, jamun and tuber crops like sweet potato, taro and yams etc. Native resources are also available in *Coleus* species, sword bean, velvet bean and several plantation crops like areca nut and coconut. Diversity also occurs for several minor fruits, such as berries and nuts. Thousand of varieties of important native or introduced staple food crops, vegetables, fruits, spices, fibre, forage and medicinal plants have developed in India under *in situ* condition making it one of the important centres of genetic diversity for these crops (Singh, 2002).

8.2.3 Ecosystem Diversity

This refers to the variety of association among organism and with the environment for utilising resources. Ecosystems differ in the species composition of their communities (association of species), and also in their physical structures. Conventionally, the world's ecosystems are broadly described in three categories, terrestrial, freshwater and marine. Most of the standard biodiversity estimates have been made on different types of terrestrial ecosystems. It is generally believed that 80 percent of all species are terrestrial and that tropical rain forests hold major proportion of species diversity. However, the taxic diversity of marine ecosystems seems to be enormously greater with doubly more phyla than that of the terrestrial ecosystems (Ray, 1988). Recent deep-sea explorations indicate that the exuberant diversity of the floor communities might rival the tropical rain forests (Rex et al., 1993). Studies of ecosystem diversity are carried out on different scales: from one ecosystem to an entire region containing many different ecosystems. Regions containing a great variety of ecosystems are rich in biodiversity, but individual ecosystems containing endemic species also make a significant contribution to global biodiversity.

8.2.4 Importance

Biodiversity is very important for survival of humans, biosphere and earth. The importance of biodiversity can be measured by considering economic (food, fibre, fuel etc.), ecological (regulating ecosystem function), cultural-anthropological, recreational and aesthetic uses. Economically, biodiversity is a fundamental basis of agricultural production and food security system. Ecologically it is a valuable ingredient of ecological stability. Aesthetically, there are many habitat and species that are attractive from recreation and tourism point of view, while many ecosystems or production systems are important for appropriate management of environment, because of their ability to absorb pollution, maintain soil fertility, micro-climate, recharge of water and in providing other invaluable services. Plant biodiversity is also important from moral, cultural, religious, aesthetic, social and scientific point of view. Many plant, and their parts are used in rituals. To name a few-flowers of *Hibiscus*, *Datura* and *Euphorbia ligularia*; leaves of *Aegle marmelos* (bael), *Eragrostis cynasuroides* (Kusa grass), rice, til, tulsi, chenopods, and odorous roots of *Dolomiaea macrocephala* (dhup). Humans are also dependent on nature for wood for timber and fuel and the increased demands for shelter and fuel have led to extensive deforestation in many parts of the world. It is estimated that four out of every five of the top 150 prescription drugs used in the US have had their origins in natural compounds. An example is aspirin a derivative of salicylic acid, which was first taken from the bark of willow trees. The process of such discoveries still continues. For example, taxol, a promising anti-cancer drug, was first extracted from a tree found in the wild: *Taxus baccata*, the pacific yew.

Agricultural biodiversity is an evolutionary divergent and highly inter-related component of biodiversity dealing with agro-ecosystems and variation in agriculture related plants, animals, fish, insects, microbes, avians etc. It is fundamental not only for fulfilment of food needs, but also several other provisions, like fodder, fibre, fuel, medicine etc., and provides farming system the means to recycle nutrients, reduce pests and disease problem, control weeds, maintain good soil and water conditions, handle climatic stresses while producing agricultural products necessary for human survival. Therefore, agricultural biodiversity is a cornerstone of stability and the basis of livelihood and sustainable development.

In spite of the growing realisation about biodiversity being fundamental to agricultural production and food security as well as ecological stability, it is being rapidly eroded and is disappearing throughout the world because of several developmental changes, including agriculture. Several of these changes jeopardise productivity, threaten food security as well as social structure and the environment.

SAQ 1

i) Where are the regions of high and low species diversity?
ii) What is genetic diversity? Give an example each of low and high genetic diversity.

8.3 IMPORTANCE OF BIODIVERSITY FOR AGRICULTURE

Biodiversity has been fundamental to agriculture and food provisions for centuries. It has provided farming systems with the capacity to evolve over the last 12,000 years. Food production depends on a variety of managed agro-ecosystems that benefit from natural resources both on farms and in surrounding habitats such as forest, grassland and aquatic ecosystems.

As you are aware, biodiversity related to agriculture is referred to as agro-biodiversity. It encompasses - genetic resources that are essential living material of plants and animals; edible plants/ crops, including landraces varieties and hybrids; livestock and edible fishes/ aquatic organisms; soil organisms vital for soil fertility and structure; naturally occurring insects, bacteria and fungi which serve as predators of pests and diseases; agro-ecosystems like polyculture/ monoculture, irrigated/ rainfed, small/ large that are valuable for nutrient cycle stability and productivity; and the wild relatives of crop plants.

There are approximately 75,000 species of edible plants world-wide (Wilson, 1988); but over the course of human civilisation, only about 7000 plant varieties have been used for food (Juma, 1989). Of these, 3000 domesticated species are being predominantly used to provide various provisions required for human survival. There is also remarkable diversity and abundance of insects, fungi, and other organisms that are valuable to the productivity of agro-ecosystem. Arthropods are the most abundant class of animals and contribute in a major way to biomass and agro-ecosystem balance. Soil, a crucial resource, is like a living organism, made up of insects, microbes and other creatures and is essential for food production. Soil organisms have a complex role in soil processes, for example, to enhance microbial activities, increase soil fertility, aeration, accelerate decomposition, and mediate transport processes in soil (Stork and Eggleton, 1992)). The habitat and species outside farming systems benefit agriculture and enhance ecosystem functions, serve as a source of host plants for natural enemies and predators of agricultural pests (Brookfield, 1995).

Many rural communities, particularly tribals obtain their daily food from several wild and non-conventional foods producing species. In addition, 95% of prescriptions of traditional systems of medicines are plant based. In sum, a knowledge of biodiversity and its conservation clearly has multiple proven benefits for agricultural productivity, sustainability and food security at all scales and in all types of agricultural systems, and can benefit agriculture in following ways:

- Increase productivity, yields and food security (and consequently economic returns)
- Reduce pressure of agriculture on fragile areas, forests and endangered species (therefore restricting deforestation)
- Build stability, robustness, and sustainability of farming systems (restricting desertification)
- Contribute to sound pest and disease management and sustainable intensification (limiting use of agrochemicals)
- Conserve soil and increase natural soil fertility and health (restricting soil degradation)
- Diversify products and income opportunities from farms
- Reduce spread of risks to individuals, communities, and nations
- Help maximise effective use of the resources and environment (restore ecological health)
- Reduce dependency on external inputs
- Increase nutritional values, and provide sources of medicine and vitamins

The breakthrough in understanding and use of genetic resources (diversity) for improvement in food production came in 19^{th} century with the discoveries of principles of inheritance of genetic diversity by the Austrian Monk, Gregor Mendel. In the 20^{th} century, N.I. Vavilov, the Russian botanist carried out systematic collection for conservation of plant diversity. He stressed the importance of maintaining diversity and its use in breeding new varieties. Later he developed the concepts of centres of origin and plant diversity across the world.

Most of the farmers incorporate multiple species and the practices that are adapted to local resources, to conserve, use and enhance biodiversity for nutrient cycling, soil fertility, and pest management. Medicinal plants are often included for health care. The farmers use diverse systems, which provide benefits to productivity, food security, resilience, risk protection, health and income generation for people. The farmers have also developed local knowledge on use of the diverse species, practices and agro-ecosystems in traditional farming, which are dynamic and ever evolving. The traditional varieties and associated knowledge are also useful to the world outside local communities. Therefore, in addition, to the above direct and indirect uses, **one of the most important use of genetic diversity, particularly in domesticated species and their wild relatives is to form the building blocks in further genetic improvement of cultivated species and other economically important species to increase productivity.** For example, a gene from wild tomato in the Peruvian Andes has increased the annual sale of commercial tomato by US$ 5-8 million in the US.

Therefore biodiversity has been the cornerstone of agriculture contributing to its sustainable development over the centuries. Recent advents in biotechnology and systematic bio-prospecting have further ensured identification of any plant species that may possibly have potential to be of use to humankind. Genetic engineering techniques have allowed the transfer of genes beyond taxonomic boundaries making all living organism part of genetic resources that can be used in genetic improvement of not only agricultural species, but other organisms as well. The examples include the transfer of cold tolerance genes from fish to wheat and the Bt gene from bacteria (*Agrobacterium tumifaciens*) to plants. Biotechnology is also helping in using micro-organisms in production of bio-fertilizers, bio-pesticides and mining etc., which has given another flip to the importance of biological diversity. Human kind therefore, has exploited plant diversity in numerous ways ever since the advent of agriculture 12,000 years ago. This diversity has been referred as 'genetic resources', which may be defined as 'genetic material of plants, which is of value as a resource for the present and future generations of people'.

SAQ 2

Apart from agriculture what are the other uses of plant biodiversity?

8.4 LOSS OF BIODIVERSITY: THREAT TO AGRICULTURE

Despite the growing realisation about the value of plant biodiversity in agricultural production food security and ecological stability, biodiversity associated with agriculture and food production is being rapidly eroded. This alarming trend includes loss of diversity at many levels – such as erosion of plant genetic resources, livestock species, insects, freshwater and soil organisms, leading to a narrowing of agro-ecosystems in general, jeopardising productivity, threatening food security. Related to this is the loss of biodiversity in "natural" habitats with the expansion of agriculture and developmental activities into new frontiers.

Genetic erosion is the loss of plant genes or genotypes that are of potential or actual agricultural value.

Genetic wipeout is total loss of genes or genotype from a population.

Modern agriculture focuses on maximising yield on per unit area basis, planting uniform modern varieties and using monoculture-farming systems with heavy doses of agro-chemicals. Although, these changes have brought increase in the world food production, they have resulted in both biophysical and socio-economic problems particularly erosion of biodiversity and degradation of natural resources, which undermine productivity and food security. Natural habitats and forests are disturbed leading to imbalances in ecology of the ecosystems. The chief contemporary cause of the loss of genetic diversity has been the spread of modern commercial agriculture. Other causes include the destruction and fragmentation of natural ecosystems, over-exploitation of resources, introduction of exotic species, human socio-economic changes, changes in agricultural practices and land-use and natural calamities. The main processes causing loss of genetic diversity of cultivated crop species are **genetic erosion**, **genetic vulnerability** and **genetic wipe out**. They are not mutually exclusive, but are in fact, inter-linked by the demands of an increasing population and rising expectations. Wider adoption of improved varieties is resulting in loss of thousands of landraces or folk varieties that have a reservoir of useful genes that has sustained them for centuries under adverse agro-climatic conditions. This is also causing genetic vulnerability of high yielding varieties. While genetic erosion is gradual, genetic vulnerability is the "thin ice" of narrow genetic base, which puts a crop at greater risk against biotic stresses, as happened with wheat stem rust in 1954 or southern corn blight in 1970 in US, and Irish potato famine in 1840 in Europe.

Box 8.2: Loss of Genetic Diversity

It is difficult to estimate how much of the genetic base of agriculturally important species has eroded. Since 1950s the varieties of corn, wheat, rice and other crops responsible for the 'Green Revolution' have squeezed out the native landraces. These modern varieties had been adopted on 40 percent of Asian rice farms in less than 15 years. Often loss of genetic diversity has dramatic impacts. For example in 1991 the worst outbreak of citrus canker disease in Brazil affected the orange trees because of their genetic similarity. In 1970, US farmers lost $1 billion to disease which swept through the genetically similar cornfields. The Irish potato famine in 1846, the failure of a large portion of Soviet wheat crops in 1972 also resulted because of genetic similarity and such outbreaks of crop failures could also occur in Bangladesh or Sri Lanka or Indonesia for which a large portion of rice crops come from single maternal plants.

Overexploitation of useful genetic resources from nature without sustainable maintenance, enhancement and conservation is another factor contributing to loss of plant species, genetic diversity. For example, *Rauwolfia serpentina* (sarpgandha) from Bastar, *Blepherispermum subsessile* (Rasna) of Chattisgarh, *Hedichyum coronaicum* (Gulbakavali) of Amarkantak and *Curcuma caesia* (Kali haldi) of sal forests are on the verge of extinction because of over collection and utilisation (Kotwal and Banerjee, 1998).

Introduction of exotic species has been another serious factor contributing to depletion of diversity of indigenous species. The introduction of *Cassia* and *Acacia* spp. has put pressure on Indian avenue tree species. Invasive species (*Lantana* and *Parthinium* spp) are a great threat to biodiversity and can become a serious menace suppressing valuable local flora. Another factor referred as genetic wipe-out involves the rapid and complete destruction of crops, habitat and forests as a result of natural calamities, social disruptions or war that can instantly eliminate promising diversity. Examples are recent forest fires in Indonesia (2000), the super cyclone in Orissa (1999) and wars in parts of Africa and Afghanistan, which have caused catastrophic losses of biodiversity. Let us discuss the direct and indirect causes of the current losses of biodiversity.

8.4.1 Monoculture

The spread of monoculture production systems (cultivation of same high yielding variety of same crop over large areas) into marginal areas and policies associated with them has resulted in genetic erosion of biodiversity. For this reason, genetic diversity is not only on the decline in farming systems, but also in many areas rich in wild relatives of food crops. With predominant changes in the production systems, diversity is being eroded, as monocultures replace poly-cultural systems. Although plant breeders develop varieties based on wide diversity of plants to incorporate desirable features, the resulting improved high yielding varieties tend to be uniform destroying the very resources on which they were developed. As a consequence thousands of traditional varieties have been eliminated from use. In addition, breeders hesitate to use wild species that have high value particularly as sources of resistance to stresses, nutrition, medicine, as well as food, either because of lack of information about their taxonomy/ breeding systems or lack of ready availability.

In India, by 1968 the so called “miracle high yielding varieties” had replaced half of the native varieties, though these were not high yielding unless they are supported with high fertilizer inputs and irrigation, which often poor farmer could ill afford (Shiva, 1991). Perpetuation of this kind of production system has lead to the loss of around 5000 traditional rice varieties from Assam, which are now available only with the genebank of International Rice Research Institute (IRRI), Manila, Philippines (Jackson, 1994). At the national level the report from Ministry of Environment (1999) says that until very recently India used to cultivate around 30,000 rice varieties, which has been reduced to 50. This kind of homogenisation has increased the risk of narrowing of the genetic base of varieties leading to their increased vulnerability to pests and diseases with adverse effects on other components of the production system. For example, in Bangladesh, the promotion of HYV rice monoculture has led to loss of diversity, including 7000 traditional rice varieties and many species of fish. This is despite the fact that production of HYV rice per acre in 1986 also dropped by 10% from 1972, in spite of 30% increase in use of agrochemical per ha. (Hussain Mian, 1994).

Livestock also suffers from genetic erosion. As per one of the FAO estimates one breed of traditional livestock is lost every week some where in the world. Many traditional breeds have been lost as farmers focus on new breeds of cattle, pigs, sheep, and chicken .Of the 3,831 breeds of cattle, water buffalo, goats, pigs, sheep, horses and donkeys believe to have existed, 16 percent have become extinct and another

15 percent are under threat (Hall and Ruane, 1993). Some 474 breeds can be regarded as rare. An additional 617 breeds have become extinct since 1892.Over 80 breeds of cattle are found in Africa, some of which are being replaced by exotic breeds (Rege, 1994). These losses weaken breeding programs, which could otherwise improve livestock hardiness. Therefore, the loss of these resources means a decline in their availability and use in breeding programmes. This can reduce a farmer's food security with increased risk for availability of a variety of foods. There are evidences to show that such changes can decrease sustainability of farming systems. Loss of diversity also means less availability of resources and opportunities to increases production in future and to overcome the new challenges.

One of the major consequences of homogenisation of varieties is their increased vulnerability to pests and diseases. Historically there are records of serious economic losses because of monoculture of uniform varieties, of which the potato famine of Ireland in the 9^{th} century that caused millions to starve is a classic example. More recently, the wine grape blight that wiped out valuable wine yards in both France and US, and the devastating *Fusarium oxysporum* attack in banana and mould infestation of hybrid maize in Zambia are some other examples (see box 8.2).

The introduction of monocultural industrialised agricultural systems has replaced polycultures, inter-cropping and agro-forestry. This has forced the farmers to accept the standardised breeds and monocultural models, eliminating mixed cropping and landraces. Hence, monoculture system has resulted in genetic erosion not only through narrowing of varieties, their vulnerability to diseases and pests, but also through narrowing of production systems that cause ecological imbalances adversely affecting natural resources.

SAQ 3

How does monoculture production system lead to loss of agro-biodiversity? Explain with examples.

8.4.2 Use of Pesticides

Although insect and fungi are usually considered to be enemies of food production there are several species that are valuable to the efficient functioning of agro-ecosystems. Many insects are beneficial to farming, for pollination, contribution to biomass, natural nutrient production and cycling, and as natural enemies of pest and diseases. Mycorrhiza, which are various species of fungi that live in symbiosis with roots of plants, are essential for nutrient and water uptake by plants. Yet, this diversity of insects and fungi is also seriously eroded in modern agricultural systems worldwide; this trend leads to increasing costs (from efforts to control pests) and declining productivity. The dependence on agro-chemicals, and particularly the heavy use or misuse of pesticides has been largely responsible for this. Agrochemicals besides killing target species also kill their natural enemies and beneficial insects. Pesticides (especially when overused) destroy a wide array of susceptible species in the ecosystem, changing the normal structure and function of the ecosystem. The disruption of agro-ecosystem balance leads to resurgence of pests and outbreaks of new pests, in addition it forces pests and pathogens to develop resistance to pesticides, which may lead to the increased use of pesticides resulting in further disruption of ecosystem. This has been referred to "pesticide treadmill".

Therefore, species richness in the soil can help increase ecosystem complexity, quality and resilience to change. In industrial agricultural systems this diversity has also been eroded by agrochemicals leading to decreased soil fertility and losses in productivity. One of the main reasons for decline in soil health include heavy uses of pesticides, soil fumigants and chemical fertilisers, which can destroy soil organisms as well as soil quality. Homogenisation of crops and varieties also reduces diversity of soil organisms depleting natural nutrients. Also, intensive tilling practices disrupt soil diversity and decline in use of natural manure, crop residues and inter-cropping, adversely affect soil health. These impacts also harm producers, for example, destruction of beneficial soil organisms like earthworm reduces the services and values of these organisms for the farmer's crops. Residual effects of agro-chemicals have often adversely affected human health.

8.4.3 Deforestation

In many parts of the world, agricultural growth has contributed to natural habitat loss, particularly in forest areas and in grassland. This has generally happened through extension of agriculture systems into **frontier zones** particularly with clearing of forests and natural vegetation for increasing food production. The expansion of agriculture into frontier areas and conversion to monocultural farming systems further reduces or erodes biodiversity of flora and fauna in the habitat landscapes (refer to subsection 8.4.1). For example, the conversion of forests to monocultural pastures and introduction of homogenous livestock's have been wide spread in America and in parts of Africa, resulting in significant decline of biodiversity. These trends are tied up with the adverse effect on natural resources such as, soil erosion, soil fertility depletion, and water depletion resulting in deterioration of productivity. Nevertheless, in some regions of Kerala, there were community-based ecosystems like mangrove ecosystems, which are special ecosystems with an association of trees, shrubs, vines and epiphytes with ability to withstand regular flooding. In back waters of Cochin these have been gradually transformed into highly productive systems based on rice during winter monsoon, and prawn and fish during southwest monsoon through inter-cropping with coconut, cocoa, pepper, vine, other spices and garden vegetables. Rice, fish and prawn continue to be produced during alternate period of solar year. It has achieved conservation of mangrove, the water for production of fish, prawn and rice. In addition, new species of plants and animals are added to the diversity of the area. This has resulted in breeding important material through induced resistance, such as salinity tolerant varieties in rice. Such wise ecological management has insured food, shelter and schools for a state with the highest population density and highest rate of literacy in India. Unfortunately, the recent developments are taking its toll and the ill-advised development plans may permanently ruin such systems.

Deforestation or loss of habitat has following primary implications:

1. Loss of wild species
2. Removal of vegetation affecting breeding areas and reducing shelter and sources of food. This may also change species composition in the area
3. Fragmentation of habitats with patches of intact and degraded lands that may harm the ecosystem, change nutrient supply and microclimatic regimes and species composition. For example, in Brazil 39 percent of land has been completely converted by the expanding agriculture, while 61 percent is being adversely affected by the above consequences.
4. Reduction in the rate of forest regeneration

In addition, deforestation adds to the social costs to society because it results in:

1. Disruption of ecosystem functions such as, water supply/ filtration provisions, cycling of nutrients and benefits of beneficial insects, flora, fauna that are vital for the life.
2. Loss of diversity of natural species and their products that can adversely affect the supply of valuable natural non-timber products such as, medicines, honey, fibres, fodder, fuel, food etc.

3. The loss of biodiversity that has adverse effects on morals and aesthetic value of all life. The harm to neighbouring farms or communities can have wider implication on regional and global ecosystems. This also affects the future generation, since they will be deprived of large number of valuable genetic resources, which might be irretrievably lost with the loss of habitats.

The concern regarding the loss of biodiversity through deforestation has mostly focused on tropical forests, because they contain unusually higher number of species. The tropical forest covers only seven percent of the earth surface but they are believed to harbour more than 50 percent of the world's plant and animal species totalling around 2.20 millions (NRC, 1993). They are being lost at a rapid pace causing serious constraints to long-term well being of the earth and humanity. These species are a source of germplasm for pharmaceuticals and fibres beside food. Local people depend on these biological resources, having intrinsic ecological benefits, which are difficult to measure economically. Unfortunately, the prevalent changes of agricultural expansion are jeopardising these resources.

Further, the loss of these resources can directly undermine production and producers on individual benefit basis because they entail:

1. Loss of beneficial flora and fauna, such as insects for pollination, natural predators for pest control and organic matter for valuable nutrients of the soil.
2. Loss of genetic resources for developing new varieties and
3. Disruption of ecosystem services such as water and nutrients cycling required for sustainability of agriculture and production.

Raven (1987) has estimated that forest areas that harbour around 50% of global species will be reduced to a tenth by 2020 AD. This could lead to the loss of 50,000 to 2,50,000 species of plants and more than 800 species of vertebrates. According to International Union on Conservation of Nature (IUCN), if the current rate of species loss continued, 25% of the world species may be lost by 2050 AD. As per Consultative Group on International Agriculture (CGIAR, 1994) estimates 50,000 of currently identified species of higher plants are under threat. In India deforestation causing habitat fragmentation, destruction, over-extraction, land use for agriculture etc., has resulted in loss of 17 species in early part of century (listed by IUCN in "extinct plant species of world"). While in the last two decades exploration, inventorisation and bio-perspective assessment of the phyto-diversity of our country have lead to the identif ication of about 1500 rare and threatened species, of both flowering and non-flowering plant groups (http://envfor.nic.in/bsi, 2002).

SAQ 4

Give at least 3 reasons why deforestation is considered one of the important reasons for loss of global biodiversity?

8.4.4 Impact of Climatic Changes

Human activities have been substantially increasing the atmospheric concentration of greenhouse gasses. These increases enhance the natural greenhouse effect and will result in additional warming of earth's surface and lower atmosphere, which may adversely affect natural ecosystems and human kind. There is also indication that rapid climatic change due to build up of greenhouse gasses in the atmosphere are another factor contributing to loss of biodiversity. The most obvious manifestation of the climatic change is warming of atmosphere that may result in rise of sea level inundating coastal and low lying areas worldwide, increase the rate of desertification, and the frequency of catastrophic weather events, such as El nino, cyclones, forest fire etc. In the hydrosphere our oceans, shared fresh water lakes and rivers are suffering from pollution and toxic contamination on a massive scale. Dramatic decline in population of aquatic species and loss of fresh water supplies for human use are just two signs that international water resources face threats.

As temperatures rise, habitats for may plants and animals will change, depriving them of their homes and niches to which they have been adapted. For example, monarch butterflies could lose their wintering habitats in the mountains of Mexico and polar bears could be affected by the loss of sea life. Many species will not be able to migrate fast enough to keep up with shifting habitat ranges. As a result, many species could become extinct. Scientists have estimated that up to 60 percent of the northern latitude habitats could be affected by global warming.

Siberian hunters along the Arctic coast have reported thunder and lightning, which has not occurred before. They also report open waters in winter. In North America, the Glacier National Park is projected to have no glaciers by 2030. They have already melted drastically since the park was created, and many that were tourist attractions in the 1920's no longer exist. Polar bears on Hudson Bay are reported to be losing weight and having fewer pups because with less ice, the bears are trapped on land longer than usual and are unable to reach the seals that are their main food supply. Warmer temperatures have led to an explosion in the population of Spruce bark beetles, which in turn have killed 38 million trees in a four million acre spruce forest in Alaska.

Dramatic changes can also be seen in the tropics. The icecap atop Mt Killimanjaro, Africa's highest mountain, has lost 85% of its volume in the last century and is apparently going to vanish within the next 15 years. In the south pacific, there have been repeated instances of coral reefs losing their colour, a bleaching effect linked to rising sea temperature and correlated with coral death, if the bleaching is prolonged. A change of several degrees is likely to melt enough polar ice that will raise the oceans between one and two feet. This is enough to increase coastal erosion and have very serious effects on the world's mangroves and corals. Raising the sea level by three feet could produce major impacts, including on agriculture in the densely populated Nile and Ganges deltas, as well as in several low lying island nations such as Maldives. In the longer term there are more ominous sea-level rise scenarios, such as the melting of the west Antarctic ice sheet. Over the space of several centuries the ice sheet could melt, as it has done previously, and raise sea level by 10 to 20 feet, enough to flood many coastal areas.

In Asia, climate change would exacerbate current threats to biodiversity, resulting from land use/ cover change and population pressure. Risks to the rich array of living species are reported. In India, 1,250 of 15,000 higher plant species are reported threatened. Similar trends are evident in China, Malaysia, Myanmar and Thailand. With a 1-m rise in sea level, the Sundarbans (the largest mangrove ecosystems) of Bangladesh are likely to disappear completely. These coastal mangrove forests provide habitat for species, such as Bengal tigers and others like spotted deer, wild boars, estuarine crocodile, fiddles crabs etc. The disappearance of native habitats may spell disaster for the flora and fauna of the region.

Similarly, land degradation in dry-land soils and burning of biomass are globally significant sources of greenhouse gas emissions. Prolonged or frequent drought and soil degradation undermine the soil's capacity to store carbon. Frequent large-scale biomass burning reduces the carbon stored in the vegetation and trees, increasing carbon emission and can contribute to further land degradation. The international community of nations has taken action against these threats by forging the Convention on Biological Diversity, and the United Nation framework Convention on Climatic Change to fulfil specific requirement designed to reduce the loss of biodiversity and to slow the rate of climatic change.

Strategies related to renewable energy sources through biomass energy production can help reduce unsustainable use of firewood and should be researched and developed. The bio-fuel activities would restore the degraded land, while the biomass cover would help produce, harvest and utilise biomass in a sustainable manner. The carbon sink protection and the activities that may enhance improving carbon storage in biomass and soils would help to prevent or control land degradation especially desertification and deforestation. Therefore, promotion of agriculture, particularly horticulture and agro-forestry in degraded lands and conservation of plant biodiversity by protecting biodiversity rich areas and/ or by establishing field gene banks will help removing barriers to implementation of climate friendly and commercially viable technologies and reducing the cost of prospective technology.

SAQ 5

a) Why are island population particularly vulnerable to extinction?
b) How does agriculture help in restricting global warming?

8.4.5 Agricultural Diversification

Much of the agricultural research and development has focused on commercial and/ or cereal production, while family grown vegetables and legumes have been overlooked. This has changed the land use pattern. Such development with diversification of cropping pattern has focused on cultivation of commercial and cereal crops leading to replacement of legumes by uniform cereals in many countries. An analysis of the area allocated among specific crops based on a proportional (%) change from 1971 to 1991 indicates that small and medium size farms increased their proportionate allocations to wheat, oilseeds, fruits/ vegetables, sugarcane, cotton and fodder, while they decreased their allocations to rice, cereals other than rice and wheat, pulses and jute, while there was a very considerably increased allocation to fodder crops, facilitating a 'livestock revolution'. However, there was a nutritionally worrisome decrease in allocation to pulses, and correspondingly a decrease in the diversity of species and varieties grown. Such changes can be detrimental, because people in many countries depend on legumes for their protein sources in diet. In India chickpea acreage dropped to half that of wheat between the 1960's and 1970's.

For poor farmers this conversion detracted the farmer from nutritional needs of the household and they had to rely on purchase of such food, which often is unaffordable and inaccessible. More the people consume uniform standardised food they do not get the variety of vitamins and minerals that are so important for nutrition and health. The decline and extinction of landraces, traditional varieties and wild foods also means a decline in valuable nutritional resources. The growing free market system of international trade in agriculture has enabled the northern countries to eat a variety of foods produced elsewhere in limited areas. These changes have brought-in the market demand for uniform high yielding varieties which poor people of south produce, but do not have access to, as these varieties are export products. Consequently, nutrition among large population of the developing world has been harmed with loss of agro-biodiversity.

The integration of freshwater prawn culture with rice farming is yet another example where diversification has led to change in land use and loss of biodiversity. Kerala and coastal Andhra Pradesh are endowed with large freshwater resources and low-lying paddy fields that have been traditionally exploited for rice cultivation. In recent times the integration of rice farming with freshwater prawn culture has given a new thrust to the economy of traditional farming. However, since the remuneration from prawn culture far exceeds than what a farmer may expect from paddy, cultivation of paddy is undertaken only to feed the prawn cultures. This has caused the discontinuation of cultivation of several varieties of rice particularly, Pokkali paddy, highly saline tolerant rice. In recent times a vast majority of the newly converted areas remains unutilised in Nellore in South India due to drought and disease problems.

One of the most influential root causes underlying agro-biodiversity losses is diversification of agriculture to green revolution model of HYV's and related industrial agriculture production system. This has promoted monoculture along with other technologies, such as irrigation, use of agrochemicals and mechanised equipments. The spread of such technologies has resulted in increased production but have provoked problems as they are inaccessible to local people and are often poorly adapted to local agro-ecological conditions. They displace indigenous practices, varieties and can increase vulnerability and risk in the farming systems. Such programs and models therefore, are provoking unanticipated problems of biodiversity losses as well as socio-economic cost. In addition, numerous policies including general agricultural development programmes, pricing, subsidies and credit packages are directly and indirectly adversely influencing biodiversity in agriculture.

SAQ 6

In what way has loss of agro biodiversity affected the nutrition of developing countries?

8.5 CONSERVATION OF BIODIVERSITY

The discussion in earlier sections clearly shows that though there is growing realisation that biodiversity is fundamental to agricultural production and food security, as well as ecological stability, it is being rapidly eroded and disappearing throughout the world because of several developmental changes, including agriculture. Several of these changes jeopardise productivity, threaten food security and result in high yield losses, as well as disrupt social structure and environment. Related to this, and equally alarming, is the loss of biodiversity in "natural" habitats with expansion of agriculture and developmental activities into new frontiers.

For instance in India deforestation, habit fragmentation, over-extraction of natural resources, conversion of land to agriculture etc., have caused loss of a large number of species during past. As per the BSI, 623 species of vascular plants are endangered since base line of 1000 threatened species of 1985 (Nayar and Sastri, 1990). Agricultural research and development policies have led to change in production systems that have worked against biodiversity and the sustainable use of genetic resources resulting in loss of traditional varieties and landraces that had survived for centuries because of their resilience against various stresses (Jackson, 1994; http, 1999).

On the basis of above discussion, it can be safely concluded that unidirectional and un-sustainable agriculture production systems conflict with conservation of biodiversity. There are cases to demonstrate multiple benefits from integrating biodiversity with agriculture. In other words, conservation and enhancement of agricultural biodiversity, essential for food production can be achieved in both small- and large-scale farms. Therefore, conservation of biodiversity either through establishing synergy between agriculture and biodiversity resolving conflicts or through integration and use of sustainable agro-ecological practices with changes in agricultural policies, institution and paradigms or through *in situ* and *ex situ* conservation approaches protecting the plant diversity in nature and in man made structure can achieve eco-friendly sustainable development. There have been efforts in this direction both at local and global level. "Convention on Biological Diversity (CBD)" is an intergovernmental agreement, which addresses the major concerns of agricultural biodiversity and recommends implementation, actions and policies for conservation, sustainable use and enhancement of agro-biodiversity through empowerment of farmers and communities, and fair and equitable distribution and sharing of benefits accruing from the use of biodiversity.

8.5.1 Integration of Conservation and Sustainable Agriculture

To overcome the conflicts between agriculture and biodiversity there is a need to develop complementarities between them in order to ensure sustainable use of bio-resources. To meet this challenge, it requires addressing causes of the full range of problems and call for change in practices, paradigms and policies. The use of experiences and practices supporting conservation and sustainable use should be spread.

The strategies for conservation are:

i) Address causes for agro-biodiversity losses

Of the forces behind agro-biodiversity loss, the promotion of practices, such as monocultures integrated with industrial agriculture has been the key factor because of being supported by institutions, private companies. This scenario requires transformation along with broader socio-economic changes at grassroot level.

ii) The key principle and practices: Conservation and Sustainable Intensification

An overview of principles and practices of agro-biodiversity for sustainable agriculture is required. The following general principle and guidelines (Table 8.1) are important to implementing methods to enhance and conserve agro-biodiversity in varying farm systems and at various scales.

Table 8.1: Key Principles to Conserve and Enhance Agro-biodiversity

Principles	Guidelines
Agro-biodiversity conservation	It should be developed within a framework of sustainable agriculture, meaning it is linked to the integration of goals of productivity, food security, social equity, health, and ecological integrity.
Agro-ecology	It is an appropriate scientific basis for agricultural development, which upholds agro-biodiversity enhancement, and provides principles for this purpose.
Empowerment of farmers and communities	It will help protection of their rights, and ensure partnerships with other social groups, which is an important social basis that would help enhance agro-biodiversity
Adaptation of methods	Adaptation to local agro-ecological and socio-economic conditions, and building upon existing fruitful methods, are essential to meet needs and build complementarities
Conservation and regeneration	It will ensure plant/ animal genetic resources and soils, and methods for sustainable intensification (using biologically based measures) needed to protect biodiversity for present farmers' livelihoods as well as future needs and ecosystem functions.
Supportive policies and institutions	Creation of supportive policies and institutions is vital to the implementation of changes to merge agriculture and biodiversity, and to ensure rights and food security of the general public.

iii) Examples of best practices to be used for enhancing agro-biodiversity

The particular practices selected for a given region or farm need to be adapted to local conditions and therefore require flexibility for adjustment and dynamic changes so as to fit into an agro-ecosystem. The practices may be related to-

a. Ecologically oriented integrated pest management.
b. Effective disease management using components of agro-biodiversity.
c. Practices for soils fertility/ health and nutrient cycling using agro-biodiversity.
d. Agro-forestry as a component of the production system for conservation of agro-biodiversity.

iv) Incorporation of farmer's knowledge/ practices and participation

It has been observed that incorporation of traditional principles and practices in the farming system is advantageous. Many experiences have shown that systematic study/refinement and inclusion of local farming practices in agricultural research and development (R & D) through participation of local people has had beneficial effect both on productivity and conservation and therefore needs to be done consistently. In other words a "user oriented" or "farmers friendly" approach is essential to develop changes.

v) Agro-biodiversity in large-scale farming

It is a common misconception that agro-biodiversity is only possible in small-scale farming. However, there are evidences to show that crop rotation, intercropping, cover crops, integrated pest management and integrated nutrient management are being effectively used in commercial systems as well. They represent sustainable approaches for intensification.

8.5.2 Merging of Agriculture and Biodiversity Goals in Habitats

In addition to developing complementarities strategies, it is required to promote practices and policies, which alleviate pressures and conserve resources in natural habitat. Intensification of sustainable *in situ* conservation is a step to achieve such a goal, but urgent work is needed in this area following the approach listed below:

i) Use of biodiversity in sustainable intensification to avoid extensification

Agro-ecological practices, such as agro-forestry, multiple cropping, crop rotation, integrated pest management, non-chemical soil management to enhance soil health, and integration of wild species are the methods that increase efficiency of resources use in sustainable way and can increase yields and also reduce or avoid expansion of farmland (Toniolo and Uhl, 1995).

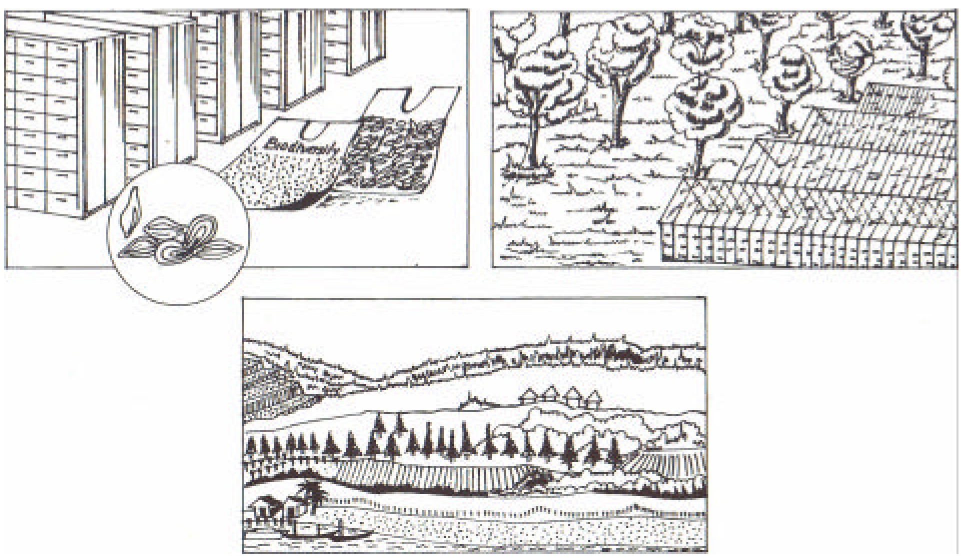
ii) Re-vegetation in agricultural lands: buffer zone, corridors, and habitat strips:

This refers to strategies for planting of native plants and trees in remnant habitat areas or forest margin. Buffer strips consist of native plants in places around existing remnants of natural vegetation to protect them from external impacts, using dense vegetation in narrow band around the edge. Corridor strips of vegetation/ trees planted between isolated habitat in remnant areas, which provide conservation "network" to enable movement of fauna and supplement habitat useful for windbreaks and erosion control.

iii) Conservation of Species/ Habitat Tied to Agriculture

Species collected from different habitats are also important as sources of food, particularly for poor farmers who benefit from diversity of nutritional sources. This biodiversity also provide valuable sources for crop breeding and pest control. There are a number of examples, where genes imported from traditional varieties or wild relatives of crop species from different countries/ regions have been used in the breeding programme protecting the crop from lethal/ severe diseases.(see section 8.3) In order to ensure that such areas remain accessible to poor communities and protected from agricultural intensification, tenure laws will need to be strengthened (Fig 8.2). Further, programmes for both *ex situ* and *in situ* conservation of wild species needs to be strengthened.

***Ex Situ* Conservation** **Field Genebanks**



***In Situ* Conservation**

Fig.8.2: Approaches to Biodiversity Conservation.

***In situ* conservation**: means conservation of genetic resources within their ecosystem and natural habitat, which ensures the maintenance and recovery of viable populations of species in their natural surroundings. It is a dynamic system that allows the species/ population to respond to the changing environment and evolves to meet the new challenges. Under *in-situ* conservation the species are allowed to grow in their natural habitat by management of ecological continuum. This can be a biosphere reserve protecting an ecosystem containing species living as interacting communities; a habitat park, national park, sanctuary, nature reserve, indigenous reserve, extractive reserve, managed forest, religious sanctuary, preservation plot, etc., conserving useful or endangered species habitat; or on-farm, ranches, home gardens etc., conserving and protecting useful or endangered landraces/ traditional cultivars and wild and weedy relatives. In conservation of agricultural biodiversity *in situ* approach is particularly important.

8.5.3 *Ex Situ* Conservation

The components of genetic material of agro-biological diversity can also be safely conserved outside their natural habitat in man made structures that have often been referred to as genebanks. These are the facilities providing support to natural perpetuation of an species or help to conserve the "genetic material" of plant origin of actual or potential value for food and agriculture. This includes reproductive or vegetative propagating material containing functional units of heredity, under conditions that are able to lim it loss of viability and genetic change to minimum level, thereby supporting conservation of true to type. They can be:

Gene bank is a facility established for the ex situ conservation of individuals (seeds), tissues, or reproductive cells of plants and animals.

A. Field Genebanks: It involves conservation of plant(s) and is partially evolutionary in nature.

1) Botanical gardens, arboreta, herbal garden, clonal repositories etc.
2) Selective conservation (conservation under selective pressures)

B. Seed Genebanks: It involves storage of seed, the physical carrier of genetic information from one generation to the other, which can survive for years under low moisture and temperature conditions. It is static in nature.

C. *In Vitro* Genebanks: Conservation of cells, tissues, organs under aseptic conditions following the principle of toti-potency, subjecting the cultures to slow growth in glass or plastic containers (static in nature).

D. Cryo-Genebanks: Cryo-preservation of seeds, organs, sperms (pollen) or cultures in liquid nitrogen between -150 to -196^{0}C following the principle of cryogenics.

E. DNA banks: conserving genomic DNA, DNA libraries, DNA clones etc. As per the objectives of conservation, the collections broadly may be of two types:

i) *Base collections:* These are unique accessions that are closest to original samples being conserved on long-term basis for posterity. They are not for distribution.

ii) *Active collections:* These refer to those collections, which are immediately available for multiplication and distribution for use in research and crop improvement.

Recognising the escalating trends in the loss of plant genetic diversity, various National and International Institutions organise planned exploration missions aimed at tapping genetic variability in different agricultural and horticultural crop species, their wild relatives and related species. The collected germplasm reveals the nature and extent of variability among different species, within species, **cultigens** etc., and also their agro-ecological/ phyto-geographical distribution. Explorations for plant genetic resources differ from floristic surveys, which are mainly undertaken to study the flora or plants of an area or its vegetation so as to list out species diversity. Plant genetic resources collection missions require considerable knowledge of plant geography, agro-ecology, plant taxonomy/ herbarium studies, ethno-botany, crop evolution and domestication, population variation and distribution and genepool sampling etc. The safest approach to ensure the success of future plant breeding programmes is to collect and maintain as much as possible of the entire genetic diversity of both cultivated species and their wild relatives.

Effective conservation of biodiversity requires precise information about how much, where and why biodiversity is being lost. Geographical information systems and remote sensing technologies and approaches allow us to assess changes in land use and land cover. This facilitates a better understanding of the causes and consequences of such changes, which in turn would enable us to develop appropriate mitigation strategies to either curtail deleterious changes or to counter their negative effects. Analysis of remote sensing imagery together with adequate ground study provides an effective way of rapidly determining forest cover over relatively large areas. Time series analysis then can help to determine changes in forest cover and gap analysis can assess the effectiveness of protected areas in conserving biodiversity. Gap analysis would also help in pinpointing and targeting areas, for organising exploration and collection missions to collect and conserve new germplasm *ex-situ* or to recollect.

SAQ 7

What is on-farm conservation and how it is different from *ex situ* conservation?

8.5.4 Addressing Policies Paradigms and Protecting Rights

Policy reforms are needed to bring out structure changes to confront the root problems, to converge agriculture and biodiversity and to ensure food security and rights of the local people. This may involve the following steps:

i) Preparation of a synopsis of initiatives effecting agro-biodiversity issues

Several international and national institutions have been involved in research, development, and policy formulation that influence use of genetic resources and diversity in agriculture (Table 8.2.). For many years these institutions have dedicated significant resources in breeding high yielding varieties in the program associated with green revolution, but in last two and a half decades these organisations and others have developed initiative to conserve genetic resources. Also, in the 1990's agro-biodiversity issues have been addressed in several international conventions and agreements, largely in reaction to global problems of genetic erosion related to ecological and economic losses. At a broad level the Earth Summit in 1993 outlined a general framework to address such matters. As an outcome, a broad and legally binding CBD (Convention of Biological Diversity) was established. This convention is an important agreement to promote conservation, sustainable use and fair distribution of biological resources globally.

Table 8.2: Major Institutions and Conventions Influencing Plant Genetic Resources

Acronym	Institution/ Conventions	Role/ Influence on Plant Genetic Resources
IPGRI	International Plant Genetic Resources Institutes	Coordinates world network of research centres, labs, and genebank concerned with PGR (formally IBPGR)
FAO-CPRG	FAO Commission on Plant Genetic Resources	Develops guidelines and norms for intellectual property rights and policies concerning plant genetic resources
FAO-SIDP	Seed Improvement and Development Program	Promotes participation of governments, NGOs, and industries to develop HYVs and related inputs
WIPO	World Intellectual Property Organisation	Oversees and establishes international norms and model laws concerning patents and control of information on PGR
UPOV	Union for the Protection of New Varieties of Plants	International Convention (held in '61, '72, '78, '91) that establishes regulations on plant innovations/ varieties
CBD	Convention on Biological Diversity (Secretariat)	International Agreement that establishes legally-binding codes of conduct, guidelines, regulations
TRIP	Trade-Related Intellectual Property Rights	Provides minimum standards for member countries on IPR, patents and plant protection, under GATT
GATT	General Agreement on Tariffs and Trade	International agreement concerning international trade and commerce, including provisions on IPR
GENE BANKS	National Seed Storage Laboratories	Maintains genetic materials as a base collection for national and for the global network of genetic resources centres

Few other institutions are focused specifically on conservation programmes in this field. Seed banks are an important component of *ex situ* conservation, storage and research on edible plants, however many of them suffer poor infrastructure and maintenance. In addition, to these initiatives, many NGO's and local organisation are increasingly interested in working to enhance, conserve and insure the rights to benefits on agro-biodiversity.

ii) Enhancing and conserving genetic resources for sustainable use

One of the most important challenges in this field is to develop appropriate policies to conserve and enhance the genetic resources and to protect the rights and welfare of the people and nations who are the users and experts on these resources. For this a summery of suggestions in general are made regarding improving *in situ* conservation, improving *ex situ* conservation, monitoring of early warning of genetic erosion in specific locations and policies and programmes to support training and public education on agro-biodiversity.

iii) Bringing reforms in breeding approaches and models

Further changes are needed in fundamental paradigms and strategies for plant breeding and agro-ecosystem management, which alleviate many specific factors leading to agro-biodiversity erosion. For example rescuing wild genetic material and their use for broadening the genetic base of cultivated species would provide greater resilience against various stresses.

iv) Changing agricultural/ economic policies to support agro-biodiversity

This would require change in policies to address causes responsible for loss of agro-biodiversity, which may include ensuring public participation, eliminating subsidies and credit on HYV, fertilizers etc., policy support and incentive for agro-ecological methods, reform in tenure/ property system, changing consumer demand etc.

Lessons from experiences show that practices and approaches to enhance agro-biodiversity pay off for both large and small-scale farmers; they also serve interests of food security and conservation. If appropriate reforms are made in policies concerning intellectual property rights, they also can contribute to broad social interests. In sum, policies and actions to support agro-biodiversity at many levels are needed, and will lead to multidimensional economic and ecological gains.

SAQ 8

In addition to *in situ* and *ex situ* conservation, give two other measures that can contribute to conservation of biodiversity for food and agriculture.

8.6 SUMMARY

In this unit you have studied that:

- There is growing realization that biodiversity is fundamental for agriculture production and food security, as well as it is a valuable ingredients for ecological stability. Despite this the biodiversity associated with agriculture and food production is being rapidly eroded and disappearing throughout the world. This alarming loss of biodiversity is occurring at many levels, including plant genetic resources, livestock species, insects, fresh water and soil organisms thereby narrowing the agro-ecosystems. These changes are threatening the productivity, food security, resulting in high economic losses at social cost. Related to this equally alarming, is the loss of biodiversity in natural habitat with the expansion of agriculture and other developmental process into new frontiers.

- Development in agriculture has often been considered opposing conservation of biodiversity, however, it is not always true and there is evidence to show that integrated biodiversity and agriculture has multiple economic and ecological benefits; thereby suggesting that agro-biodiversity is critical for food production, ecosystem health and for economical and eco-friendly development. Recognising these concerns, the Convention on Biological Diversity (CBD) has mandated actions for nations and institutions for conservation, sustainable use and fair and equitable distribution of benefits derived of agricultural biodiversity.

- Agro-biodiversity is the fundamental feature of farming systems. Since early days, it consists of diversity at genetic, species and ecosystem level. The conservation practices followed for agro-biodiversity are part of rich cultural diversity and local knowledge.

- In spite of the importance of agricultural biodiversity it is being eroded globally and one of the main reasons is increased vulnerability of crops to pests and diseases. This situation has arisen because of monoculture production system. The monoculture production system has been further expanded to high input industrial agriculture, which has promoted use of agrochemicals leading to further loss of diversity in natural habitats including tropical forests, grasslands and wetlands and contributing to climatic changes further destroying the biodiversity at global level. The underlying reasons for this situation are complex, consisting of a mix of policies, practices and pressures for economic and agriculture growth, as well as demographic changes and disparities in the control of resources.

- Consequently conservation of agricultural biodiversity is needed. Efforts have been made in this direction both at local and global levels with the establishment of agreement like CBD. Yet much more is to be done to implement the agreements of the Convention to strengthen, expand and coordinate the initiatives for agro-biodiversity conservation and enhancement. In developing such strategies, following principles are important, agro-biodiversity conservation, agro-ecology, empowerment of farmers and communities, adaptation of methods needed to build complementarities, conservation and regeneration and creating supportive policies and institutions. These are needed at all levels. These types of policies and practices promise win-win opportunities that merge goals of agriculture and biodiversity, and will lead to socio-economic and ecological gains.

8.7 TERMINAL QUESTIONS

1. Describe the components that constitute biodiversity and how are they measured
2. What are genetic resources, describe the constituents of plant genetic resources and how do they differ from the constituents of agro-biodiversity?
3. When did the Convention on Biological Diversity (CBD) come into existence and what are its primary objectives?
4. How does biodiversity contribute to research and development of agriculture to increase food productivity.
5. How does genetic homogeneity of crop species enhances genetic vulnerability to pests and diseases? What type of agricultural practices can help minimise it?
6. What are the impacts of environment changes on biodiversity in general and agriculture in particular?
7. Explain the potential use of wild and weedy relatives in major crop species

8. What is *in situ* and *ex situ* conservation, how they can be utilised as complementary approaches for sustainable conservation and use of genetic resources?

9. Explain Vavilov's centres of origin and how do they differ from the centres of diversity.

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