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National Open University
School of Interdisciplinary and
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MSD-012
Ecosystem and Natural Resources

Block

4

AGROBIODIVERSITY

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BLOCK 4 AGROBIODIVERSITY

This is the fourth block of the course Ecosystem and Natural Resources. After discussing the importance of biodiversity in the previous block, we will now focus on the issues related to agrobiodiversity, factors responsible for depleting biodiversity, sustainable use of agrobiodiversity and sustainable management of biodiversity.

Unit 1 gives an overview of the concept of agrobiodiversity, its importance, implications of agrobiodiversity for sustainability of agriculture and climate change.

Unit 2 presents a comprehensive picture of different aspects of agrobiodiversity loss, factors that are responsible for depleting status of agrobiodiversity, effects of different agricultural practices on agrobiodiversity and existing gaps in the current knowledge.

Unit 3 provides you an insight of different aspects of sustainable use of agrobiodiversity, different issues related to sustainable use of plant and animal genetic resources and their implications on the food security and farmers livelihood. Legislative frameworks related to protection of plant varieties for fair and equitable sharing of benefits arising from commercial use of agrobiodiversity in global and Indian context and role of community in agrobiodiversity conservation has also been highlighted.

Unit 4 furnishes the implications of current global pattern of development on agrobiodiversity, the complex socio-economic issues and identifies major challenges and opportunities which have potential role to decide the future scenario of agrobiodiversity. The main focus of the unit, however, remains to explore the alternative ways towards sustainable management of agrobiodiversity.

UNIT 1 AGROBIODIVERSITY: CONCEPT, ORIGIN AND IMPORTANCE

Structure

1.0 INTRODUCTION

Agrobiodiversity refers to the variety and variability of living organisms that contribute to food production systems and associated activities. Agrobiodiversity in its widest interpretation includes biodiversity of cropped areas as well as that of outside the farm boundaries which are beneficial for agriculture and which play a role in the regulation of ecosystem functions. Human civilization has been founded on the services provided by agrobiodiversity, the most obvious of which is the production of foods, fuels and fibres in agricultural landscapes. Such services have been and continue to be the basis for economic development for a large proportion of the human population.

We have already discussed about biodiversity and its importance in the Block 1 of this course. In the present unit we have given an overview of the concept of agrobiodiversity. While describing the scope or components of agrobiodiversity, the unit also explains the various aspects of its importance. Implications of agrobiodiversity for sustainability of agriculture and climate change have particularly been emphasized. While the present unit covers introductory aspects of agrobiodiversity, details about depletion, management and ongoing issues related to agrobiodiversity have been covered in Unit-2, Unit-3 and Unit 4 of this block respectively.

1.1 OBJECTIVES

After reading this unit, you will be able to:

- explain the concept and scope of agrobiodiversity.
- describe the importance of agrobiodiversity.
- discuss the implication of agrobiodiversity on climate change and sustainability of agriculture.

1.2 THE CONCEPT OF AGROBIODIVERSITY

Agrobiodiversity is a shortened form of agricultural biodiversity. Agrobiodiversity refers to the variety and variability of living organisms that contribute to food production, agriculture and associated activities in their largest sense. The fifth conference of parties to the Convention on Biological Diversity decided on the following definition: "the term agricultural biological diversity refers to, in a general fashion, all of the elements constituting biological diversity which relate to food production and agriculture, as well as all of the components of biological diversity which constitute the agroecosystem: the variety and variability of animals, plants, microorganisms, at the genetic, specific and ecosystem levels, necessary for the maintenance of the key functions of the agroecosystem, its structures and its processes".

Agricultural biodiversity is a vital sub set of biodiversity. It is a use of life, i.e. ancillary biotechnologies, by mankind whose food and livelihood security depend on the sustained management of those diverse biological resources that are important for food and agriculture. Although the term agricultural biodiversity is relatively new as it has come into wide use in recent years, the concept itself is quite old. It is the result of the careful selection and inventive developments of farmers, livestock breeders, forest workers, fishermen and indigenous peoples throughout the world over millennia. In fact, agrobiodiversity is the result of the interaction between the environment, genetic resources and management systems and practices used by culturally diverse people. Thus, it encompasses the variety and variability of animals, plants and micro organisms that are necessary for sustaining key functions of the agroecosystem, including its structure and processes for, and in support of, food production and food security. Local knowledge and culture can therefore be considered as integral parts of agrobiodiversity, because it is the human activity of agriculture that shapes and conserves this biodiversity.

You should know that biodiversity is the basis for agricultural production. On one hand, it is the origin of all crops and domestic livestock and the variety within them. On the other hand, components of wild biodiversity in agricultural and associated landscapes provide and maintain ecosystem services that are essential to agricultural production (e.g. pollination). Similarly, on one hand agricultural biodiversity is the result of human activities and management; on the other hand human life is dependent on it for the immediate provision of food and other natural resources based goods, as well as for the maintenance of areas of land and waters that will sustain production and maintain agroecosystems and the wider biological and environmental services.

In the face of global environmental changes, there is growing need for scientific knowledge on the role of agrobiodiversity and human well-being. Worldwide there is consensus among scientists that conservation and sustainable use of the diversity of cultivated plants and domestic animal breeds is the key to the attainment of Millennium Development Goals declared by UN.

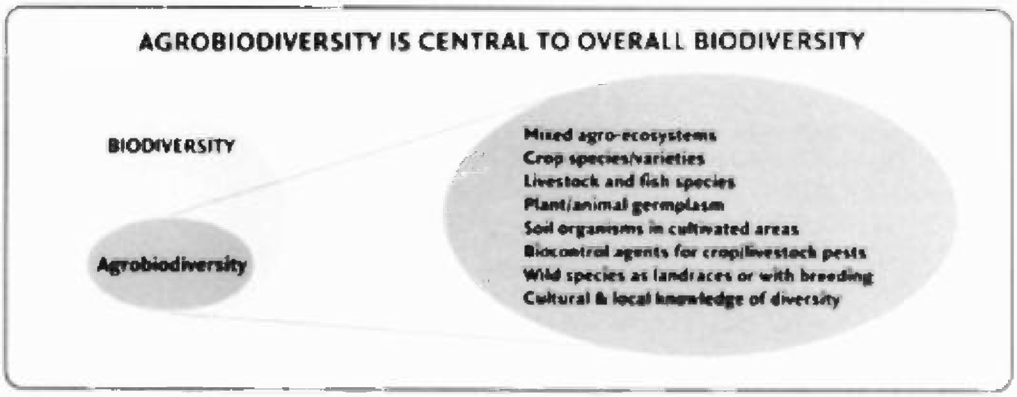

Fig. 1.1: Agrobiodiversity: A subset of biodiversity

1.3 SCOPE OF AGROBIODIVERSITY

Agrobiodiversity is a subset of general biodiversity. It further comprises genetic, population, species, community, ecosystem, and landscape components and human interactions with all these. Agrobiodiversity, in its widest interpretation includes biodiversity of cropped areas as well as that of outside the farm boundaries which are beneficial for agriculture and which play a role in the regulation of ecosystem functions. A distinction can be made between the planned or controlled biodiversity and the associated biodiversity . Planned agrobiodiversity is the crops and animal husbandry systems chosen by the farmer, while the associated biodiversity refers to organisms (soil fauna, weeds etc.) which colonise the agroecosystem without human support.

Planned biodiversity or harvested species include domesticated crop species (e.g., cereal, pulses, vegetables, fruits, spices etc.), wild relatives of crops, including woodland and aquatic plants (used for food and other natural resources based products etc.), domestic and wild animals (used for food, fibre, milk, hides, furs, power, organic fertilizer etc.), fish and other aquatic animals.

Associated agrobiodiversity or non-harvested species includes two categories. First category includes non-harvested species within production agroecosystems that perform supporting or regulating functions in agroecosystems. For example, it includes diversity of soil organisms, pollinators and pest predators. These play very important role in soil nutrient turnover, soil organic matter dynamics, pollination, biological pest control etc. Second category includes non-harvested species in the wider environment that support food production agroecosystems including species that are present in field margins, surrounding forest, rangeland, and aquatic ecosystem. For example, leaf litter produced by forest tree species add to soil fertility of agricultural fields: hence such forest trees can be included under agrobiodiversity.

In conventional studies on agrobiodiversity, major attention is given to cultivated varieties and to crop wild relatives. Cultivated varieties can be broadly classified into "modern varieties" and "farmers' or traditional varieties". Modern varieties are the outcome of formal breeding programmes and are often characterised as 'high yielding'. The short straw wheat and rice varieties of the Green Revolution are examples of modern varieties. In contrast, farmer's varieties (also known as landraces) are the product of breeding and selection carried out by farmers over the generations. Together, these varieties represent high levels of genetic diversity and are therefore the focus of most crop genetic resources conservation efforts. Aquatic diversity is also an important component of agricultural biodiversity. Fresh water fish, marine fish, prawn-fish and many aquatic plants provide much of the food supply as well as substantial income to the communities living in coastal areas or near water bodies.

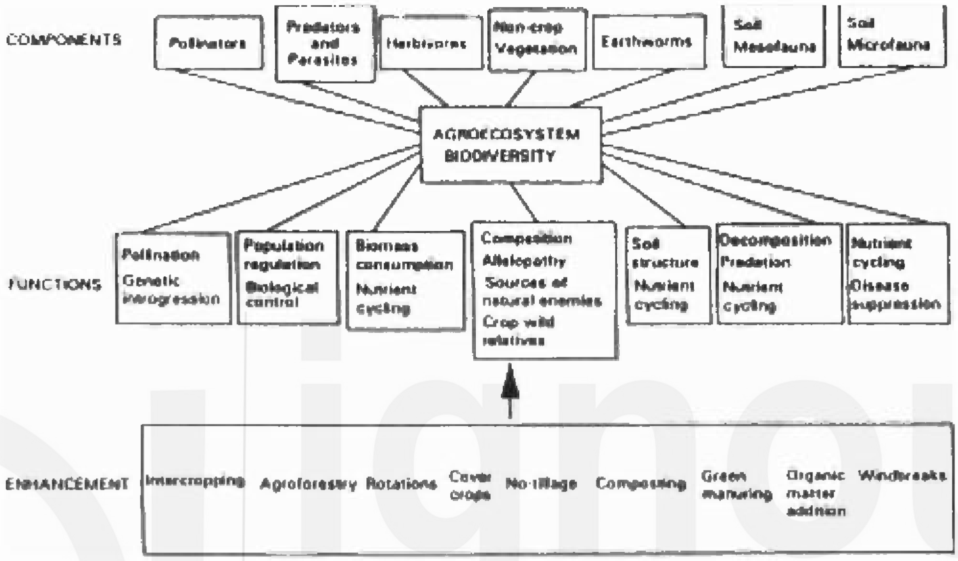

Fig.1.2: The components, functions, and enhancement strategies of biodiversity in agroecosystems (Altieri, 1994).

1.4 DISTINCTIVE FEATURES OF AGROBIODIVERSITY

We know now that agrobiodiversity is a subset of biodiversity. As discussed easiest that while general biodiversity includes diversity of all life forms, agrobiodiversity refers to the diversity that relate to food production and agriculture, as well as all of the components of biological diversity which constitute the agroecosystem. General biodiversity is represented by about 1.8 million species of plants and animals on the earth. This is the number of species that have been described till date. Agrobiodiversity, on the other hand, is represented by about 40,000 species of plants and animals. These species are used by human society for different purposes in different parts of the world.

According to FAO (1999) the agrobiodiversity is defined as the variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil micro-organisms, predators, pollinators), and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest and aquatic) as well as the diversity of the agro-ecosystems.

There are several distinctive features of agrobiodiversity that makes it different from other components of general biodiversity. Some of these features are described as below:

- While the evolution of general biodiversity is a natural process, that of agrobiodiversity is largely facilitated by human intervention in form of farming, breeding and selection of different crops. Many components of agrobiodiversity would not survive without such human interference.

- Many economically important agricultural systems are based on 'alien' crop or livestock species introduced from elsewhere for example, horticultural production systems or Friesian cows in Africa. This creates a high degree of interdependence between countries for the genetic resources on which our food systems are based.

- While the general biodiversity is often described at the level of species, agrobiodiversity is generally described at both the levels: genetic diversity (or diversity within species) as well as species diversity.

- Conservation of agrobiodiversity is inherently linked to its sustainable use in agroecosystems and has close relationship with livelihood of farmers' community. Local knowledge and culture are integral parts of agrobiodiversity management.

- Preservation through establishing protected areas is less relevant for agrobiodiversity. In industrial type agricultural systems, however, much of the crop diversity is now held *ex situ* in gene banks or breeders' materials rather than on farm.

1.5 CENTRES OF ORIGIN OF CULTIVATED PLANTS

Agrobiodiversity is the outcome of thousands of years of effort by farmers' communities. Selection and breeding created species, breeds and varieties that are adapted optimally to the conditions in their regions of origin and best match the needs of their breeders. The origin of crop plants is now basic to plant breeding in order to locate wild relatives, related species, and new genes (especially dominant genes, sources of disease resistance). Knowledge of the origins of crop plants is vitally important in order to avoid genetic erosion due to the loss of germplasm as well as loss of habitat. Germplasm preservation is accomplished through gene banks and preservation of natural habitats (especially in centers of origin).

There are eight centres of origin of agrobiodiversity which are known as Vavilov's centres of origin of cultivated plants. They were first described by Dr. Nikolai Ivanovich Vavilov. All the crop varieties used at present originated from one of these centres. These areas continue to be home to the largest pool of agricultural biodiversity. A glimpse of the centers of origin of major crops shows that no country is self-sufficient in crop genetic resources and there is high degree of inter-dependency across the world. For example, nearly half of India's main crops have been introduced from abroad. Same is the case with other nations.

Brief descriptions of these centres along with sequence of centres and subcentres and names of crop varieties that originated there are given below. These centres have also been depicted in the given world map according to the sequence code described in the text.

Fig.1.3: World map showing location of eight centres of origin of cultivated plants

Source: http://en.wikipedia.org/wiki/Center_of_origin

1) South Mexican and Central American Center

Includes southern sections of Mexico, Guatemala, Honduras and Costa Rica.

- Grains and Legumes: maize, common bean, lima bean, tepary bean, jack bean, grain amaranth
- Melon Plants: malabar gourd, winter pumpkin, chayote
- Fiber Plants: upland cotton, bourbon cotton, henequen (sisal)
- Miscellaneous: sweetpotato, arrowroot, pepper, papaya, guava, cashew, wild black cherry, chochenial, cherry tomato, cacao

2) South American Center

62 plants listed; three subcenters

2) Peruvian, Ecuadorean, Bolivian Center:

- Root Tubers: Andean potato, Other endemic cultivated potato species. Fourteen or more species with chromosome numbers varying from 24 to 60, Edible nasturtium
- Grains and Legumes: starchy maize, lima bean, common bean
- Root Tubers: edible canna, potato
- Vegetable Crops: pepino, tomato, ground cherry, pumpkin, pepper
- Fiber Plants: Egyptian cotton
- Fruit and Miscellaneous: cocoa, passion flower, guava, heilborn, quinine tree, tobacco

2A) Chiloe Center (Island near the coast of southern Chile)

- Common potato(48 chromosomes), strawberry.

2B) Brazilian-Paraguayan Center

- manioc, peanut, rubber tree, pineapple, Brazil nut, cashew, purple granadilla.

3) Mediterranean Center

Includes the borders of the Mediterranean Sea. 84 listed plants.

- Cereals and Legumes: durum wheat, emmer, Polish wheat, spelt, Mediterranean oats, sand oats, canarygrass, grass pea, pea, lupine.
- Forage Plants: Egyptian clover, white clover, crimson clover, serradella
- Oil and Fiber Plants: flax, rape, black mustard, olive.
- Vegetables: garden beet, cabbage, turnip, lettuce, asparagus, celery, chicory, parsnip, rhubarb.
- Ethereal Oil and Spice Plants: caraway, anise, thyme, peppermint, sage, hop.

4) Middle East

Includes interior of Asia Minor, all of Transcaucasia, Iran, and the highlands of Turkmenistan. 83 species.

- Grains and Legumes: einkorn wheat, durum wheat, poulard wheat, common wheat, oriental wheat, Persian wheat, two-row barley, rye, Mediterranean oats, common oats, lentil, lupine.
- Forage Plants: alfalfa, Persian clover, fenugreek, vetch, hairy vetch.
- Fruits: fig, pomegranate, apple, pear, quince, cherry, hawthorn.

5) Ethiopia

Includes Abyssinia, Eritrea, and part of Somaliland. 38 species listed; rich in wheat and barley.

- Grains and Legumes: Abyssinian hard wheat, poulard wheat, emmer, Polish wheat, barley, grain sorghum, pearl millet, African millet, cowpea, flax, teff.
- Miscellaneous: sesame, castor bean, garden cress, coffee, okra, myrrh, indigo.

6) Central Asiatic Center

Includes Northwest India (Punjab, Northwest Frontier Provinces and Kashmir), Afghanistan, Tadjikistan, Uzbekistan, and western Tian-Shan. 43 plants.

- Grains and Legumes: common wheat, club wheat, shot wheat, peas, lentil, horse bean, chickpea, mung bean, mustard, flax, sesame.
- Fiber Plants: hemp, cotton.
- Vegetables: onion, garlic, spinach, carrot.
- Fruits: pistacio, pear, almond, grape, apple.

7) **Indian Center**

Two subcenters.

7) Indo-Burma: Main Center (Hindustan): Includes Assam and Burma, but not Northwest India, Punjab, nor Northwest Frontier Provinces, 117 plants.

- Cereals and Legumes: rice, chickpea, pigeon pea, urd bean, mung bean, rice bean, cowpea.
- Vegetables and Tubers: eggplant, cucumber, radish, taro, yam.
- Fruits: mango, orange, tangerine, citron, tamarind.
- Sugar, Oil, and Fiber Plants: sugar cane, coconut palm, sesame, safflower, tree cotton, oriental cotton, jute, crotalaria, kenaf.
- Spices, Stimulants, Dyes, and Miscellaneous: hemp, black pepper, gum arabic, sandalwood, indigo, cinnamon tree, croton, bamboo.

7A) Siam-Malaya-Java: statt Indo-Malayan Center: Includes Indo-China and the Malay Archipelago, 55 plants.

- Cereals and Legumes: Job's tears, velvet bean.
- Fruits: pummelo, banana, breadfruit, mangosteen.
- Oil, Sugar, Spice, and Fiber Plants: candlenut, coconut palm, sugarcane, clove, nutmeg, black pepper, manila hemp.

8) **Chinese Center**

A total of 136 endemic plants are listed in the largest independent center.

- Cereals and Legumes: e.g. broomcorn millet, Italian millet, Japanese barnyard millet, Koaliang, buckwheat, hull-less barley, soybean, Adzuki bean, velvet bean.
- Roots, Tubers, and Vegetables: e.g. Chinese yam, radish, Chinese cabbage, onion, cucumber.
- Fruits and Nuts: e.g. pear, Chinese apple, peach, apricot, cherry, walnut, litchi.
- Sugar, Drug, and Fiber Plants: e.g. sugar cane, opium poppy, ginseng camphor, hemp.

1.6 ANIMAL GENETIC DIVERSITY

Livestock or animal genetic diversity constitutes the vital part of agrobiodiversity. The 40-plus livestock species contributing to today's agriculture and food production are shaped by a long history of domestication and development. Selection pressures resulting from environmental stress factors, and the controlled breeding and husbandry imposed by humans, have combined to produce a great variety of genetically distinct breeds. This diversity, developed over thousands of years, is a valuable resource for today's livestock keepers. Genetically diverse livestock populations provide a greater range of options for meeting future challenges, whether associated with environmental change, emerging disease threats, new knowledge of human nutritional requirements, fluctuating market conditions or changing societal needs.

The State of the World's Animal Genetic Resources for Food and Agriculture is the first global assessment of livestock biodiversity. Drawing on 169 Country Reports, contributions from a number of international organizations and twelve specially commissioned thematic studies, it presents an analysis of the state of agricultural biodiversity in the livestock sector; origins and development, uses and values, distribution and exchange, risk status and threats and of capacity to manage these resources institutions, policies and legal frameworks, structured breeding activities and conservation programmes.

Thousands of years of animal husbandry and controlled breeding, combined with the effects of natural selection, have given rise to great genetic diversity among the world's livestock populations. High output animals intensively bred to supply uniform products under controlled management conditions coexist with the multipurpose breeds kept by small scale farmers and herders mainly in low external input production systems.

Effective management of animal genetic diversity is essential to global food security, sustainable development and the livelihoods of hundreds of millions of people. The livestock sector and the international community are facing many challenges. The rapidly rising demand for livestock products in many parts of the developing world, emerging animal diseases, climate change and global targets such as the Millennium Development Goals need to be urgently addressed. Many breeds have unique characteristics or combinations of characteristics i.g. disease resistance, tolerance of climatic extremes or supply of specialized products that could contribute to meeting these challenges. However, evidence suggests that there is ongoing and probably accelerating erosion of the genetic resource base.

1.7 THE ROLE OF AGROBIODIVERSITY

Over millennia, human well being has been founded on the services that biodiversity provides, the most obvious of which is the production of foods, fuels and fibres in agricultural landscapes. Such services have been and continue to be the basis for economic development for a large proportion of the human population. In a wider context, biodiversity in agricultural landscapes serves critical functions that enhance the environmental base upon which agriculture depends. These functions include regulating and supporting services such as water purification, nutrient cycling, and soil formation.

Experience and research have shown that agrobiodiversity can:

- Increase productivity, food security, and economic returns
- Reduce the pressure of agriculture on fragile areas, forests and endangered species
- Make farming systems more stable, robust, and sustainable
- Contribute to sound pest and disease management
- Conserve soil and increase natural soil fertility and health
- Contribute to sustainable intensification of agriculture
- Diversify products and income opportunities
- Reduce or spread risks to individuals and nations

- Help maximize effective use of resources and the environment
- Reduce dependency on external inputs
- Improve human nutrition and provide sources of medicines and vitamins, and
- Conserve ecosystem structure and stability of species diversity.

1.8 AGROBIODIVERSITY AND FOOD SECURITY

FAO (2005) estimated that at least 852 million people worldwide suffer from hunger and malnutrition; 80% of them live in rural areas. Tackling hunger has for many years been one of the issues at the heart of international cooperation. Eradicating extreme poverty and hunger by achieving food security is one of the eight Millennium Development Goals.

As per the World Food Summit of 1996 in Rome "Food security is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life". There are three core determinants of food security: availability, access and utilization. Availability involves the production of a sufficient quantity of food that is available at the right time and in the right place. Access concerns the demand side, in particular the problems of people who cannot buy enough food even if it is available. Utilization involves the correct storage, processing and combination of foods.

Humans use at least 40,000 species of plants and animals. People around the world depend on these species for their food, shelter, clothing and energy requirement. Food is obtained from various food crops and animal species. Genetic resources are particularly relevant for food sector. There are several thousand species of edible plants, but only 20 kinds of plants are cultivated to produce about 80% of world's food. The three major crops wheat, rice and maize contribute about two third of total food production. There is enormous untapped potential for increasing the range of food products suitable for human consumption.

Higher yields of major food crops achieved through the "Green Revolution" have contributed to food security in many countries. But even where "high-tech agriculture" predominates, greater species diversity could in the long term help to develop new products, stabilize yields and optimize the utilization of resources such as fertilizers or water for irrigation. Regions such as deserts or mountainous areas that are disadvantaged by their natural situation have seen very little rise in yields over recent decades. It is in these very areas that local plant species and animal breeds are often advantageous, since they are optimally adapted to the local conditions. Together with traditional knowledge and practices, they help farmers make the best use of limited resources.

Filling one's belly is often not enough. People who live on the brink of poverty often lack a varied diet. Yet the appropriate use and combination of foods can contribute to long-term health, particularly among children. Leafy vegetables, fruits, legumes, roots, tubers, spices, and herbs are essential for human nutrition and complement staple crops such as rice or maize. Many leguminous crops, such as cowpea and winged bean, are excellent sources of protein and micronutrients. Home gardens often accommodate a particularly rich diversity of crops. As home gardens are usually run by women, most of the production is directly used for cooking, benefiting all the family. The establishment and appropriate support of home gardens is therefore a promising option for improving the nutritional status of poor people both in rural and periurban areas. They also serve to raise awareness of the importance of the diversity of traditional food plants.

1.9 IMPORTANCE OF WILD VARIETIES AND SPECIES

The reservoir of genetic traits present in wild varieties and traditionally grown landraces is extremely important in improving crop performance. Important crops, such as the potato, banana and coffee, are often derived from only a few genetic strains. Improvements in crop species over the last two centuries have been largely due to harnessing genes from wild varieties and species. Interbreeding crops strains with different beneficial traits has resulted in more than doubling crop production in the last 50 years as a result of the Green Revolution.

Wild plants serve as supplement to human food in many parts of the world. This greatly helps to reduce human pressure on agriculture, particularly in the region where agricultural production is challenged by many constraints like population, land degradation etc. For example, throughout the West African Sahel, rural women carefully collect the fruit, leaves and roots of native plants for use in the families' diet. These supplement the agricultural grains (millet, sorghum) that provide only one part of the nutritional spectrum and may fail in any given year. More than 800 species of edible wild plants have been catalogued across the world. In addition to supplying calories and protein, wild foods supply vitamins and other essential micro-nutrients. However, in some areas, pressure on the land is so great that wild food supplies have been exhausted. The term 'wild-food' is used to describe all plant resources that are harvested or collected for human consumption outside agricultural areas in forests, savannah and other bush land areas. For instance, fruits and berries, from a wide range of wild growing plants, are typically referred to as 'wild-food'.

1.10 AGROBIODIVERSITY AND LIVELIHOOD OF FARMERS

Many farmers, especially those living in environments where high-yield crop and livestock varieties do not prosper, rely on a wide range of crop and livestock types. This helps them maintain their livelihood in the face of pathogen infestation, uncertain rainfall and fluctuation in the price of cash crops, socio-political disruption and the unpredictable availability of agro-chemicals. So called minor or underutilized crops or companion crop are frequently found next to the main staple or cash crops. They often grow these minor crops along with the major crops. Their importance is, however, often misjudged. In many cases, from a livelihoods perspective, they are not minor or underutilized as they can play a disproportionately important role in food production systems at the local level. Plants that will grow in infertile or eroded soils, and livestock that will eat degraded vegetation, are often crucial to household nutritional strategies. In addition, rural communities, and the urban markets with which they trade, make great use of these companion crop species.

Fallow fields and wild lands can support large numbers of species useful to farmers. In general, poor households rely on access to wild foods more than the wealthier. Wild foods are incorporated into the normal livelihood strategies of many rural people, pastoralists, shifting cultivators, continuous croppers or hunter-gatherers. Wild food is usually considered as a dietary supplement to farmers' daily food consumption, generally based on their crop harvest, domestic livestock products and food purchases on local markets.

One of the causes of food insecurity is chronic or temporary shortage of money. Even if food is available in sufficient quantity and quality, not everyone has the resources to buy it. Improving the income situation of such people is an essential part of improving food security. Special, often little known plant varieties and livestock breeds offer potential for income generation. This may involve processing to food, medicines, cosmetics and craft products, or developing new markets and market niches for such products. The organic and fair trade markets provide potential for long-term initiatives in these areas.

Check Your Progress 1

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) How does agrobiodiversity differ from general biodiversity?

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2) How is agrobiodiversity related to livelihood of smallholder farmers?

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1.11 AGROBIODIVERSITY AND ECOSYSTEM SERVICES

In general, the Millennium Ecosystem Assessment (MA) aimed to promote understanding of the value of biodiversity to human society, and conversely costs associated with actual and projected biodiversity losses. In addition to an inventory of global biodiversity, this international assessment implemented and widely publicized the concept of ecosystem services. The report also provided a general methodology to quantify the consequences of changes in biodiversity on ecosystems and on different components of human well-being.

Goods and services provided by biodiversity are numerous in number and there are several ways in which they can be studied. As stated in the block of this course, the Millennium Ecosystem Assessment, undertaken under CBD framework, identified 24 ecosystem services that are directly or indirectly related to biodiversity and that make a direct contribution to human well-being. We know from previous section that the Assessment was intended to examine the changing status of these services so as to devise conservation strategy for future. We know that these 24 goods and services can be described in four categories: goods, cultural services, regulating services and supporting services. Besides these there are some unknown benefits from biodiversity.

In the context of agrobiodiversity, these services have further been redistributed into three categories which signify different aspect of food production system:

- First category includes sustainable production of food and other agricultural products emphasizing both strengthening sustainability in production systems at all levels of intensity and improving the conservation, sustainable use and enhancement of the diversity of all genetic resources for food and agriculture, especially plant and animal genetic resources, in all types of production systems
- Second category includes biological or life support to production emphasizing conservation, sustainable use and enhancement of the biological resources that support sustainable production systems, particularly soil biota, pollinators and predators.
- Third category includes ecological and social services provided by agro-ecosystems such as landscape and wildlife protection, soil protection and health (fertility, structure and function), water cycle and water quality, air quality, CO_2 sequestration, etc.

1.12 AGROBIODIVERSITY AND CLIMATE CHANGE

The implications of climate change for agriculture have opened a new window in the discussion of agrobiodiversity. Environmental change is one of many factors that are responsible for reducing the diversity of crops and livestock. Five climate change related factors can be identified: the rise in temperatures, changes in precipitation patterns, the rise of sea levels, higher incidence of extreme weather events and the increase of greenhouse gases, especially carbon dioxide in the atmosphere. The rise in temperature commonly known as global warming, is probably the most obvious phenomenon of climate change. It is expected that the increases will be highest in the tropics and subtropics, and there will be large-scale extinction of species, lower agricultural yields and a major change in cropping systems. Indirect temperature effects will also be significant, including the increased evaporation of water from the soil, the accelerated decomposition of organic matter, and the increased incidence of pests and diseases affecting both animals and plants.

Dramatic implications are expected for agriculture and food supply, although with large regional differences. It is predicted that the 40 poorest countries, located predominantly in tropical Africa and Latin America, may lose 10 - 20 percent of their grain growing capacity due to drought by 2080. It is also argued that many rain fed crops in some areas are already near their maximum temperature tolerance, and their yield may fall sharply with a further temperature rise. By contrast, yield increases are expected in temperate regions; a country like China could experience a 25 percent rise in production. Tragically, these changes are likely to hit the world's poorest people hardest.

Combating such changes requires a two pronged strategy of mitigation and adaptation. On the one hand all possible efforts must be made to reduce greenhouse gas emissions and to slow climate change. On the other, fast and appropriate action is needed to enhance capacity to adapt to irreversible changes already inherent in the system but not yet fully visible. Agrobiodiversity provides potential option to combat against the challenges posed by climate change. Agricultural genetic resources are not only a victim of climate change; they are of fundamental importance for adaptation to this change and are crucial to coping with the problems it poses. There are a number of plants and animals which presently have no economic value, but these can cope with the changing climatic situation.

However, climate change requires not only that genetic resources should be conserved, but also that they should adapt to climate change. Plants, animals and ecosystems have the capacity to adjust to changes in factors such as heat, drought or salinity, and this enables us to cope with the consequences of changing environments. This capacity is an outcome of genetic diversity. Adaptation is a dynamic process brought about through an organism's interaction with its environment. It is not a matter of, for example, deep freezing a drought resistant strain of millet for many decades in a gene bank, but rather of continuing to grow and breed the seeds in the fields, where they are exposed to a wide range of agricultural and ecological conditions. The resistance of plants to environmental stress (e.g. drought tolerance) is a multigenetic characteristic. It is difficult to achieve through genetic engineering and best developed through classical breeding under *in situ* conditions.

The social dimension of these adaptive processes is no less important. The poor sectors of the population, in particular, must be enabled to adapt to changing environmental conditions; traditional knowledge and social organization must be strengthened and developed. Climate change induced environmental stress may in fact exceed the adaptive capacity of animals and plants to cope with it. Nevertheless, the *in situ* approach offers a genuine chance to shape a future worth living.

1.13 AGROBIODIVERSITY FOR SUSTAINABILITY OF AGRICULTURE

For more than 10,000 years, farmers have been selecting plants to develop varieties that produce higher yields, are less susceptible to diseases, and that show a certain degree of uniformity in germination and ripening, which makes harvesting easier. Through this selection of crop plants and by cultivating them under various, in some cases harsh environmental conditions, over the millennia a rich diversity of agricultural crop species has developed. In India, for instance, until a few decades ago up to 30,000 rice cultivars were grown.

During the past 150 years this trend has reversed. The biological diversity of crop plants has since been dwindling. Fewer and fewer species are being used for agriculture, and no more than three of them (rice, maize and wheat) supply 60 percent of the world's food. Not only are fewer and fewer plant species used for agriculture, but genetic diversity within species is also declining. Plant breeding and commercial seed production have contributed substantially to the reduction of genetic diversity within individual species. The number of varieties of any given crop is constantly decreasing and the varieties are becoming increasingly uniform, while certain characteristics are being lost during the process. In view of the necessity of adapting to climate change and of ensuring global food security, this "genetic erosion" threatens the existence of the global population. In order to meet these and future challenges, some of which are still unknown, humanity needs whatever genetic diversity still exists. At the same time, conservation of biological diversity must be reconciled with agricultural intensification.

In the 50 years from 1950 to 2000, global grain production almost tripled. This increase was mainly made possible through progress in plant breeding, intensive nitrogen fertilisation and effective herbicides for weed control. This productivity increase, however, was mainly achieved on fertile soils, under optimal growing conditions, and only a small percentage of farmers benefited. A large proportion of all farms are still smallholdings. These mostly involve no external inputs such as fertilizer and pesticides, because the classic intensification strategies are not suitable for such farms. In the 1980s, around 60 percent of all agricultural land was still being farmed in this manner. Even though this figure is probably smaller today, traditional agriculture still contributes substantially to world food production and is fundamental to food security.

In order to feed the increasing world population, further agricultural intensification is required. The world population is expected to grow to approximately 9 billion people by 2050. The potential to expand agricultural land to feed this population, however, is very limited. In order for intensification to be sustainable, agriculture must start using nutrients and energy more efficiently, it must sustain ecosystems and their functions while conserving biodiversity and it has to be climate-friendly. One possibility for increasing the yield potential of traditionally farmed lands is increasing on-farm species diversity. But crops and their varieties that are expected to produce higher yields on poorer sites must have traits different to the high yielding varieties used on agriculturally favourable sites.

The search for alternatives started 50 years ago and led to today's method of evolutionary plant breeding. In order to generate new varieties,, breeders systematically utilize farmers' local varieties that are genetically diverse and have adapted ecologically. This involves bringing together seed from different origins and recombining them through crossbreeding. Evolutionary breeding with composite crossbred populations is a very promising method for agricultural intensification, particularly under ecologically disadvantageous conditions, and for adapting crops to climate change-induced environmental changes. Participatory plant breeding is one good approach to ensure agrobiodiversity conservation as well as agricultural sustainability. In contrast to classical approaches, breeding is not done by breeders alone, nor does it take place only in experimental fields or in laboratories. Farmers are involved throughout the entire breeding process and most of the breeding takes place in their fields. This helps to ensure better ecological adaptability of the crops towards the conditions of farmers' field.

Check Your Progress 2

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) How is agrobiodiversity related to global climate change?

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2) How does agrobiodiversity contribute in sustainability of agriculture?

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1.14 LET US SUM UP

- Agrobiodiversity refers to the variety and variability of living organisms that contribute to food production systems and associated activities.
- Agrobiodiversity is the result of the careful selection and inventive developments of farmers, livestock breeders, forest workers, fishermen and indigenous peoples throughout the world over millennia.
- The 40-plus livestock species contributing to today's agriculture and food production are shaped by a long history of domestication and development.
- Agrobiodiversity provides means of livelihood to small holder farmers across the world particularly to those who are living in harsh environment or less industrialized regions.
- As per Millennium Ecosystem Assessment identified and assessed 24 ecosystem goods and services associated to biodiversity.
- Climate change may lead to erosion of several crop varieties. A number of crop varieties will be able to cope up with changing climate.
- Agrobiodiversity helps to maintain essential ecosystem functions. It helps agroecosystems to cope up with uncertainties posed by climate change, market risks and socio-economic disruption.

1.15 KEY WORDS

Agroecosystems	:	Ecosystems represented by agriculture or similar food production system
Varieties	:	Taxonomic units represented by genetic variation within a species
Planned Biodiversity	:	Species or varieties of crops, or breeds of animals which perform certain production function
Associated Agrobiodiversity	:	Agrobiodiversity other than planned biodiversity that performs supporting or regulatory functions in agroecosystems
Smallholder Farmers	:	Farmers with small landholdings and belonging to low or middle income group
Malnutrition	:	Health disorders caused by consumption of food which lack one or more ingredients of balanced diet like protein, vitamins etc.
Genetic Erosion	:	Loss of genetic diversity within a species.

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- http://www.cbd.int/agro/
- http://www.icar.org.in/node/1333
- http://www.agrobiodiversity-diversitas.org/
- http://agrobiodiversityplatform.org/
- http://www.fao.org/biodiversity/en/

1.17 KEY TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Your answer must include the following points:
   - Agrobiodiversity include biodiversity that is related to agroecosystems
   - Unlike general biodiversity, human intervention has been the integral part of agrobiodiversity
2) Your answer must include the following points:
   - Several indigenous crops are particularly grown by smallholder farmers and these are source of income
   - Agrobiodiversity helps farmers to maintain their livelihood in the face of ecological, climatic and socio-economic uncertainties

Check Your Progress 2

1) Your answer must include the following points:
   - Climate change may lead to erosion of several crop varieties
   - A number of crop varieties will be able to cope up with changing climate
2) Your answer must include the following points:
   - Agrobiodiversity helps to maintain essential ecosystem functions
   - It helps agroecosystems to cope up with uncertainties posed by climate change, market risks and socio-economic disruption

UNIT 2 SHRINKING AGROBIODIVERSITY: CAUSES AND CONSEQUENCES

Structure

2.0 INTRODUCTION

We know that agricultural biodiversity is a subset of general biodiversity. It includes all forms of life directly relevant to agriculture. In the past five decades, intensification and the homogenization of agroecosystems have led to significant losses in agrobiodiversity, including the loss of crop and livestock species, genetic diversity, as well as crop associated biodiversity. Intensification and the homogenization of agricultural ecosystems have led to significant losses in agrobiodiversity, including the loss of crop and livestock species and genetic diversity, as well as crop-associated biodiversity. The loss of agrobiodiversity is perceived as potential threat to long term sustainability of agricultural systems and on food security, especially of poor populations living in marginal lands.

The present Unit gives a comprehensive picture of dif ferent aspects of agrobiodiversity loss. While exploring different factors that are responsible for depleting status of agrobiodiversity, the present unit identifies intensification of agriculture as the dominant force which has drastically reduced agrobiodiversity. Effects of different agricultural practices on agrobiodiversity have been explained in fair details. At the end of the unit, existing gaps in the current knowledge have been identified.

2.1 OBJECTIVES

After reading this unit, you will be able to:

- describe the magnitude by which agrobiodiversity is shrinking;
- explain the causes and consequences of shrinking agrobiodiversity; and
- underline the gaps in present knowledge about agrobiodiversity loss.

2.2 SHRINKING AGROBIODIVERSITY: AN OVERVIEW

Biodiversity is vital for human survival. The major challenge of agricultural development in the twenty first century is, to secure food for all peoples while protecting the agricultural biodiversity on which both we and future generations largely depend. The Millennium Ecosystem Assessment concluded that human activities have led to a more rapid loss of biodiversity on Earth over the past 50 years than ever before in human history. The assessment argued that the loss of species and the progressive homogenization of many ecosystems continue to be one of the main threats to the survival of our natural as well as socioeconomic systems. Intensification and the homogenization of agricultural ecosystems have led to significant losses in agrobiodiversity, including the loss of crop and livestock species and genetic diversity, as well as crop associated biodiversity such as pest suppressive biodiversity pollinators, soil biodiversity etc.

Agrobiodiversity loss chiefly comprises erosion of genetic diversity. Genetic erosion in agrobiodiversity is the loss of genetic diversity, including the loss of individual genes, and the loss of particular combinants of genes (or gene complexes) such as those manifested in locally adapted landraces. The term genetic erosion is sometimes used in a narrow sense, such as for the loss of alleles or genes, as well as more broadly, referring to the loss of varieties or even species. Without proper management of agricultural biodiversity some key functions of the agroecosystem may be lost, such as maintenance of nutrient and water cycles, pest and disease regulation, pollination and hand erosion control. Erosion of agricultural biodiversity has negative impacts on the long term sustainability of agricultural systems and on food security, especially of poor populations living in marginal lands.

There are a number of factors that are responsible for agrobiodiversity erosion. Replacement of local varieties by high yielding or exotic varieties or species is one such factor. A large number of varieties are dramatically reduced when commercial varieties (including GMOs) are introduced into traditional farming systems. Many researchers believe that the main problem related to agro-ecosystem management is the general tendency towards genetic and ecological uniformity imposed by the development of modern agriculture. Pressures for that ecological uniformity on farmers and breeders are caused by the food industry demand for more and more raw materials consistency.

Agricultural intensification, and its corollary, the simplification of agricultural landscapes, are the major factors responsible for the loss and profound modification of biodiversity, in particular over the last few decades. Agricultural areas represent a majority of the land area of many countries. It holds the key to the conservation of world's remaining biodiversity. Innovative biodiversity rich farming systems can potentially be high yielding and sustainable, and thus support persistence of wild species by limiting the adverse effects of agriculture on natural habitats. Adoption of farming practices that utilize and conserve biodiversity may ultimately improve environmental quality and limit agricultural expansion.

2.3 PATTERN OF AGROBIODIVERSITY LOSS

Since the 1900s, some 75 percent of plant genetic diversity has been lost as farmers worldwide have left their multiple local varieties and landraces for genetically uniform, high-yielding varieties. 30 percent of livestock breeds are at risk of extinction; six breeds are lost each month. Today, 75 percent of the world's food is generated from only 12 plants and five animal species. Of the 4 percent of the 250 000 to 300 000 known edible plant species, only 150 to 200 are used by humans. We know from the previous units that only three species rice, maize and wheat, contribute nearly 60 percent of calories and proteins obtained by humans from plants. Animals provide some 30 percent of human requirements for food and agriculture and 12 percent of the world's population live almost entirely on products from ruminants.

More than 90 percent of crop varieties have disappeared from farmers' fields; half of the breeds of many domestic animals have been lost. With the disappearance of harvested species, varieties and breeds, a wide range of unharvested species also disappear. In fisheries, all the world's 17 main fishing grounds are now being fished at or above their sustainable limits, with many fish populations effectively becoming extinct. Loss of forest cover, coastal wetlands, other 'wild' uncultivated areas, and the destruction of the aquatic environment exacerbate the genetic erosion of agrobiodiversity. Locally varied food production systems are under threat, including local knowledge and the culture and skills of farmers. Of a total of 7616 livestock breeds studied by FAO, around 20 percent breeds are classified as at risk.

2.4 REASONS OF DECLINE IN AGROBIODIVERSITY

Throughout the twentieth century the decline has accelerated, along with increased demands from a growing population and greater competition for natural resources. There are many reasons for the decline in agrobiodiversity. The major factors leading to agrobiodiversity erosion are rapid expansion of industrial and green revolution, globalization of food system and marketing, replacement of traditional varieties by improved or exotic varieties and species, land clearing, overexploitation of species, population pressure, environmental degradation, overgrazing, and changing agricultural systems and policies.

The rapid expansion of industrial and Green Revolution agriculture is one of the major driving force that led to remarkable decline in crop diversity. This also includes intensive livestock production, industrial fisheries and aquaculture. Some production systems use genetically modified varieties and breeds. Relatively few crop varieties are cultivated in monocultures and a limited number of domestic animal breeds, or fish, are reared or few aquatic species cultivated.

Globalization of the food system and marketing are the other major driving forces. The extension of industrial patenting, and other intellectual property systems, to living organisms has led to the widespread cultivation and rearing of fewer varieties and breeds. This results in a more uniform, less diverse, but more competitive global market. As a consequence there have been changes in farmers' and consumers' perceptions, preferences and living conditions; marginalization of small scale, diverse food production systems that conserve farmers' varieties of crops and breeds of domestic animals; reduced integration of livestock in arable production, which reduces the diversity of uses for which livestock are needed; and reduced use of 'nurture' fisheries techniques that conserve and develop aquatic biodiversity.

Replacement of local varieties by improved or exotic varieties and species is the main cause of the genetic erosion of crops as reported by almost all the countries. Frequently, genetic erosion occurs as old varieties in farmers' fields are replaced by newer. Genes and gene complexes, found in the many farmers' varieties, are not contained in the modern varietes. Often, the number of varieties is reduced when commercial varieties are introduced into traditional farming systems. While FAO (1996) states that some indicators of genetic erosion have been developed, few systematic studies of the genetic erosion of crop genetic diversity have been made. Furthermore, in the FAO Country Reports (1996) identified that nearly all countries confirm genetic erosion is taking place and that it is a serious problem.

2.5 THREATS TO ANIMAL GENETIC DIVERSITY

FAO's Global Databank for Animal Genetic Resources for Food and Agriculture contains information on a total of 7616 livestock breeds. As far as livestock breeds are concerned around 20 percent of reported breeds are classified as at risk. Of even greater concern is that during the last six years 62 breeds became extinct amounting to the loss of almost one breed per month. These figures present only a partial picture of genetic erosion. Breed inventories, and particularly surveys of population size and structure at breed level, are inadequate in many parts of the world. Population data are unavailable for 36 percent of all breeds. Moreover, among many of the most widely used high output breeds of cattle, within breed genetic diversity is being undermined by the use of few highly popular traits for breeding purposes.

A number of threats to genetic diversity can be identified. Probably the most significant is the marginalization of traditional production systems and the associated local breeds, driven mainly by the rapid spread of intensive livestock production, often large scale and utilizing a narrow range of breeds. Global production of meat, milk and eggs is increasingly based on a limited number of high output breeds those that are most profitably utilized in industrial production systems. The intensification process has been driven by rising demand for animal products and has been facilitated by the ease with which genetic material, production technologies and inputs can now be moved around the world. Intensification and industrialization have contributed to raising the output of livestock production and to feeding the growing human population. However, policy measures are necessary to minimize the potential loss of the global public goods embodied in animal genetic resource diversity.

Acute threats such as major disease epidemics and disasters of various kinds (droughts, floods, military conflicts, etc.) are also a concern particularly in the case of small, geographically concentrated breed populations. Threats of this kind cannot be eliminated, but their impacts can be mitigated. Preparedness is essential in this context as adhoc actions taken in an emergency situation will usually be far less effective.

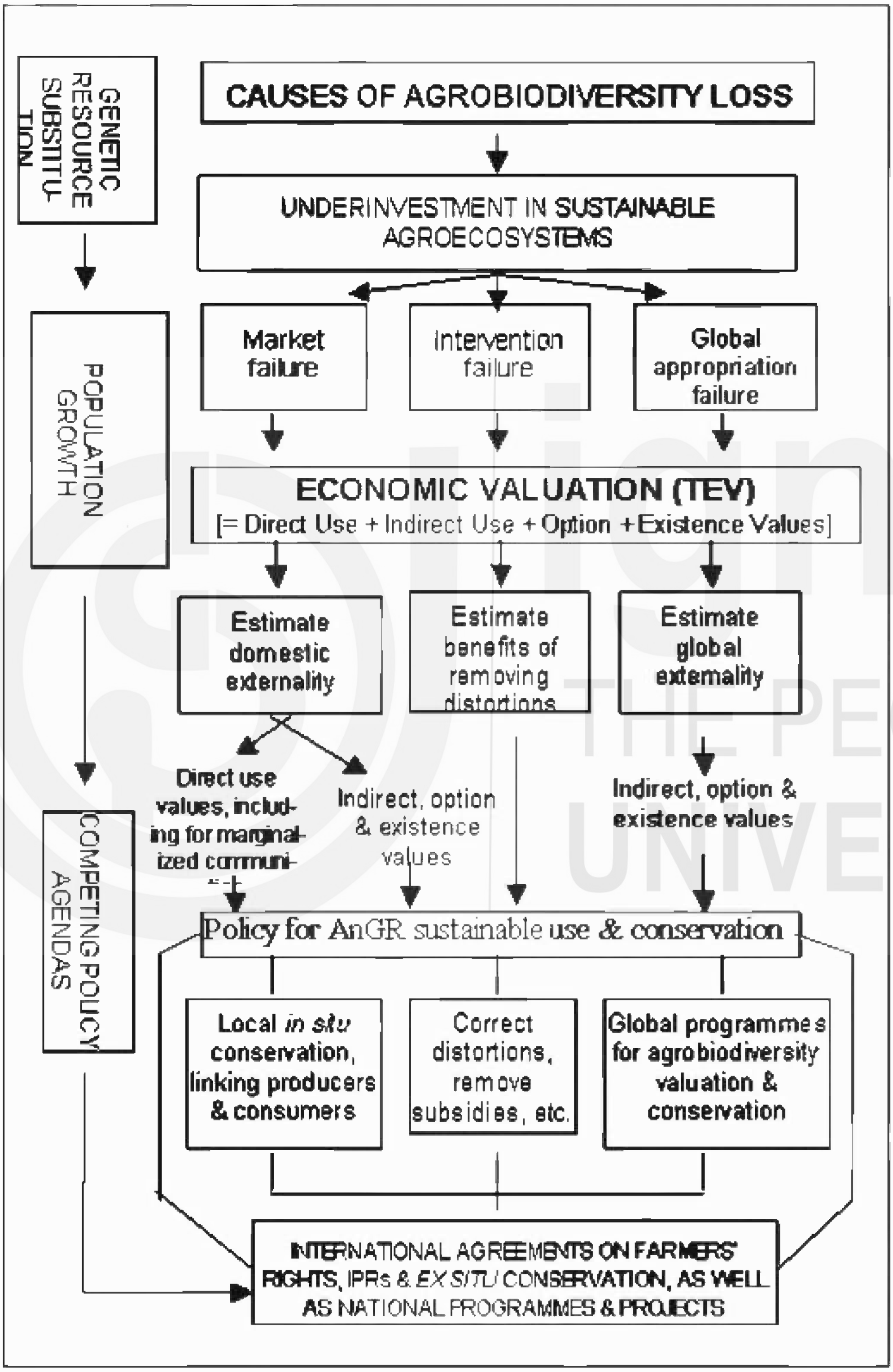

Fig. 2.1: Schematic summary of factors affecting global agrobiodiversity loss. TEV = total economic value. Source: Adapted from Brown et al. (1993)

Policies and legal frameworks influencing the livestock sector are not always favourable to the sustainable utilization of animal genetic resources. Overt or hidden governmental subsidies have often promoted the development of large scale production at the expense of the smallholder systems that utilize local genetic resources. Development interventions, disease control strategies and post-disaster rehabilitation programmes can also pose a threat to genetic diversity, if they do not ensure that the breeds used are appropriate to local production environments and the needs of the intended beneficiaries. Implementing appropriate strategies for the low external input production systems of the developing world is a great challenge. Pastoralists and smallholders are the guardians of much of the world's livestock biodiversity. Their capacity to continue this role may need to be supported for example, by ensuring sufficient access to grazing land. It is essential that conservation measures do not constrain the development of production systems or limit livelihood opportunities. Achieving such a balance itself is a challenge.

Check Your Progress 1

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) Why did Green Revolution led to loss of agrobiodiversity?

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2) How has globalization affected agrobiodiversity?

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2.6 EFFECTS OF AGRICULTURE ON AGROBIODIVERSITY

Agriculture is the dominant anthropogenic factor controlling biodiversity. Agricultural areas represent a majority of the land area of many countries: 75% in England, 60% in France, 57% in India etc. While recent preoccupations with biodiversity losses are mostly focused on the destruction and transformation of natural habitats, numerous human managed landscapes also contain species diversities comparable to those of natural ecosystems, with in particular the persistence of numerous threatened species. If the conservation of biodiversity is to be based on the protection of 5% of currently existing natural habitats, to be successful, it will also require the recognition of the remainder of the area of a country.

The agricultural regions of numerous countries are over 2000 years old. Over time, a large number of wild species have become adapted to these landscapes, with the result being the development of species rich, human modified landscapes. In parallel, continued growth of human populations and their resulting occupation of space have resulted in the destruction of natural habitats. Some species have thus lost their initial habitat and have become almost entirely dependent on secondary habitats, primarily agricultural, to survive.

Studies have quantified the influence of agricultural management on biodiversity, both in terms of the equilibrium between natural and managed areas and of the quality of areas managed by agriculture. Evaluating and understanding the effects of agriculture on biodiversity is a major challenge in the establishment of generic knowledge useful for stakeholders in this domain of scientific research. By definition agricultural activity seeks to manage and control biodiversity, but in very different manners depending on the agroecosystem. The effects of different practices on biodiversity have been briefly discussed in the following subsections.

Available knowledge in the literature shows that the ability of landscapes to provide for different species depends both on their structure and the quality of each of their components. These factors are determined by the agricultural mosaic, and by the suite of agricultural practices employed by farmers. Increased landscape complexity, represented in agricultural landscapes by the proportion of cropped areas to semi natural elements and by their spatial arrangement, favours biodiversity overall, as does the use of non intensive agricultural practices.

Agriculture exerts an influence on biodiversity via a complex network of mechanisms. These include the impacts of agricultural practices at the plot level on the environmental conditions experienced by organisms, and also the impact of agriculture on habitat heterogeneity, in terms of the diversity of agroecosystem elements (cropped areas, field margins, wooded areas, irrigation canals etc.) and the diversity of agroecosystems and natural ecosystems at larger scales such as the landscape (and in particular, the region).

2.6.1 Effects of Annual and Perennial Crops

Cropped fields generally have specific ecological characteristics including: large fluxes of materials and a strongly human constrained trophic structure, which creates systems in permanent disequilibrium requiring constant human intervention. Cropped fields are subject to intense disturbance (interventions for the control of pest species, massive removals of primary production), relative spatial uniformity and a periodic "resetting". The use of synthetic phytosanitary products and repeated deep ploughing, as well as fertilisation, appear as major factors in the decline of the species richness and abundance of numerous organisms (soil microorganisms, soil fauna, insects, plants, amphibians, birds). These effects are at the same time both intentional, when acting to favour the crop, and non-intentional when they exert negative effects on populations of crop pest natural enemies or earthworms.

In woody perennial crops (e.g., orchards, vineyards), due to the permanence of their host plant, numerous pest species remain continually present and their control requires the repeated application of phytosanitary products, which consequently is the major factor affecting biodiversity in these systems. Apple orchards, for example, are subject to up to thirty pesticide applications per year, and are treated for long periods of 6 to 8 months per season (from budding up until harvest). There are direct effects (mortality, decreases in fecundity), of greater or lesser severity depending on the products used, on the target organisms (arthropod pests) as well as for other species present in the orchard (other arthropods, birds, small mammals etc.). There are also indirect effects for these same groups due to the suppression of resources (weedy plants, prey species), and the alteration of trophic chains. The chemical protection of an orchard has significant negative effects on insect functional diversity and compromises the natural regulation of some pests of apples.

2.6.2 Effects of Soil Cultivation, Crop Rotation and Water Management

Ploughing when used in a repeated manner has a negative effect on the species richness or abundance of many organisms. It selects for weedy species depending on the ability of their seeds to survive in the soil. The abundance of soil macrofauna, and in particular earthworms is significantly reduced by deep ploughing. In the case of repeated ploughing and unfavourable conditions (low organic resources, constraining microclimatic conditions), the species richness of macrofauna communities can also be reduced. While the abundance of microfauna and mesofauna is less affected than the macrofauna by the different techniques of soil cultivation, the profound modifications of trophic and microclimatic conditions resulting from these interventions strongly modify the composition of their communities.

While it is often stated that crop rotations induce higher densities and diversities of soil organisms than continuous cropping, observations indicates that this is only the case where a perennial is introduced into the rotation. Where this is not the case, the opposite result is often observed. Nevertheless, the use of any form of rotation, breaks the developmental cycle of pest species and weeds specific to some crops, and is useful for the control of other pests. Rotation can thus allow for a reduction in pesticide use, with consequent positive effects on biodiversity.

Water management at the plot level, through drainage or irrigation, can have variable effects on biodiversity. Drainage can have a negative effect on groups found in wetlands, for which recent major declines pose a problem for biodiversity conservation. Irrigation has an overall favourable effect on soil fauna but leads to a decrease in plant diversity. Soil fauna biodiversity is particularly affected by soil moisture conditions.

2.6.3 Effects of Application of Fertilizers and Pesticides

Crop fertilisation has globally positive results on the abundance and growth of living organisms in the soil and vegetation, as long as this does not reach toxic levels. However, effects on the species richness of plants and insects are generally negative. Increasing fertiliser application has effects mainly at two levels: firstly on the communities of soil organisms directly affected by changes in the physical and chemical environment with consequent effects on species richness and composition, and secondly on the biodiversity of organisms linked to the nutritional status of plants, through modifications of trophic chains.

In general, the increase in fertilisation allowed by the use of synthetic fertilisers, has resulted in the homogenisation of many environments in terms of resource availability, and has lead to the disappearance of species adapted to low nutrient environments (a well documented phenomenon for arable weeds), and the replacement of specialist species by generalists (birds). Mineral nitrogen fertilisation appears as one of the main factors responsible for the decrease in species richness of cropped fields and in adjacent boundary areas. Organic fertilisation appears to have more subtle effects, in particular in microbial communities. It is worth noting that beyond these effects at the plot scale, increased fertiliser use has effects on aquatic ecosystems both continental and coastal (eutrophication resulting from the leaching of nutrients, nitrogen and phosphorus in particular), and on the totality of terrestrial ecosystems due to volatilisation and the accumulation of mineral deposition of atmospheric origin (nitrogen in particular).

Pesticides or synthetic phytosanitary products are considered as one of the major factors responsible for the decline of biodiversity in the agroecosystems of industrialised countries. In general, the effects of phytosanitary products on arthropods, and in particular on crop pests and their natural enemies, depends on their life history, demographic parameters and developmental stage at the time of application. Insecticides that are non-toxic for particular useful species (natural enemies, pollinators) are in reality very rare. Most pesticides have a more or less global effect on arthropod communities. Insecticides can be more toxic than herbicides for soil fauna and in particular earthworms and soil arthropods. Fungicides are even more toxic. The impact of herbicides on soil food webs is generally indirect (reductions of vegetation and soil organic matter). Effects on vertebrates are in particular known for birds and amphibians. These can be direct, due to the use of high doses, or indirect, sometimes even with low doses (for example due to bioaccumulation).

Herbicide use induces a major reduction in the number of plant species and of their biomass in cropped fields, and also in their margins. The continued utilisation of the same herbicide molecules has caused the development of some species populations resistant to the applied molecule. Such phenomena may be accentuated with the establishment of crops of herbicide resistant genetically modified organisms.

2.6.4 Effects of Grass Cover, Grazing, Fallowing and Abandonment

Permanent grasslands, characterised by a perennial multi species, or at least multi year, vegetation cover, do not in general receive pesticides (some cases of the use of selective herbicides against specific species do however exist). While the term permanent grassland covers a large variety of situations, from those heavily fertilised and intensively exploited to rangelands and summer pastures experiencing low stocking rates, these areas generally have a biodiversity considerably greater than that of cropped fields and are often considered as semi-natural areas. The major factors influencing their biodiversity are grazing regimes and the practices of mowing or hay cutting and fertilisation.

In general, a high grazing intensity tends to have a marked negative effect on the species richness of different types of organisms: plants, arthropods, small mammals and soil fauna. However, bird richness may be high in heavily grazed pastures, even if the abundance of each species is reduced. Moderate levels of grazing lead to an increase in plant species richness and in the abundance of some soil organisms. For plants, species richness tends to decrease when grazing pressure is very low, especially in productive grasslands (with productivity more than 2 t/ha). It is worth noting that the number and functional diversity of some soil organisms (earthworms, some nematodes, amoebas, mycorrhizal fungi) is positively related to plant species richness. Consequently, moderate intensities of grazing can increase the species richness of numerous groups of organisms. In functional terms, an increase in grazing pressure selects for plants with shorter life spans, smaller size and with efficient resource acquisition abilities (photosynthesis, mineral element absorption).

The weedy flora found in fallows is made up of species whose seeds were contained in the soil seed bank. Consequently, these are the same species as normally found in the plot and no additional biodiversity (for example rare arable weeds) is to be expected from the simple placing of a plot in fallow. However, the lower management pressure experienced in a fallow can allow the recruitment of some rare species. The absence of soil cultivation also results in annual species becoming replaced by biennials or perennials. Fallows established to benefit the environment and wild animals can be sown with mixes of species that are more or less diverse (cereals, legumes, buckwheat etc.). Their faunal richness depends on the nature and botanical complexity of their vegetation.

The effect on biodiversity of the abandonment of a previously exploited area depends strongly on its initial state. In the case of cropped fields (cereals, vineyards, orchards etc.) characterized by an environment initially poor in species, species richness increases during the first few years following abandonment for practically all groups of organisms including microorganisms. In functional terms, abandonment leads to a replacement of plant species with a short life span, small size, wind dispersal and high resource acquisition abilities, by species with opposite characteristics and which are often animal dispersed (birds in forested stages).

2.6.5 Effects of Modifications of Landscape Complexity and Fragmentation

Historically, the development of agriculture has been accompanied by major transformations of landscapes and the destruction of natural habitats. More precisely, land use change and the modification of agricultural practices towards greater intensification, since the 1950's, has resulted in a major modification in the structure of landscapes which can affect biodiversity. These structural modifications have mainly included reductions in the heterogeneity or complexity of landscapes, emphasized by the effects of successive agricultural policies. In parallel, the abandonment of marginal agricultural areas has lead to a homogenisation of vegetation cover which can also affect biodiversity.

Increasing heterogeneity in agricultural landscapes has, in general, a positive effect on biodiversity. It increases the species richness of the majority of animal and plant groups and contributes to increases in the abundance of most of these. Recent landscape transformations in regions of intensive agriculture, by favouring open areas often to the detriment of semi-natural elements, have lead to decreases in biodiversity. At the landscape scale, poorly represented landscape elements and non-agricultural elements play a major role as refuge habitats for numerous species, and thus play a large role in increasing biodiversity.

The presence of grasslands in a landscape, and in particular low productivity grasslands, is favourable for biodiversity whether this is, for example, for birds, earthworms or soil microfauna. The effects of landscape structure are generally more pronounced for above-ground arthropods and vertebrates than for plants, soil fauna and microorganisms. From a functional point of view, landscape heterogeneity favours insects that are pollinators or natural enemies of crop pests and limits insect pests. Landscape homogenisation leads to a simplification of communities by decreasing the presence of rare species and increasing that of common species.

Landscape heterogeneity, agricultural practices, and production systems act simultaneously on biodiversity, sometimes in synergy and sometimes in opposition, with the effect of one limiting the potential effects of others. There also exists, in the majority of cases, a strong correlation between the intensification of conventional agriculture and landscape homogenisation, with increasing plot sizes and the fragmentation of semi-natural elements.

The fragmentation of semi-natural habitats, with associated effects of decreases in the total number of effectively favourable habitats, a decrease in patch size and increases in fragment isolation, has a generally negative effect on biodiversity. Such fragmentation leads to a decrease in the species richness of most taxonomic groups, even for some low mobility species such as collembolans or soil micro-arthropods, and the decline of isolated plant populations. The response of different groups to landscape fragmentation depends on their scale of perception and mobility. As a general rule, specialist species are more sensitive to fragmentation than generalists.

2.6.6 Effects of Organic Agriculture and Genetically Modified Organisms (GMO)

Impacts of conventional and organic agriculture on biodiversity have been compared by some studies. Changing from conventional agricultural production to an organic one often has an overall positive effect on biodiversity. The richness of plants, soil microorganisms, vertebrates and arthropods increases. The abundance of invertebrate predators also increases, while the responses of soil fauna are either positive or neutral. Organic agriculture is more favourable to predator species which are often involved in the biological control of pests. For soil fauna, the beneficial effects of organic agriculture occur not only in cropped fields but also in the neighbouring margins and hedgerows. Adopting organic agricultural practices will have few effects on biodiversity in simplified, intensively managed landscapes, due to a lack of source populations. However, in landscapes which retain some semi natural habitats and source populations, organic agriculture has a particularly positive effect.

The impacts of GMO's on biodiversity are specific to the varieties cultivated and to the genes introduced. In general this consists of varieties resistant to a non-selective herbicide, or made tolerant to an insect pest. In the case of resistance to a herbicide, the effects include more complete vegetation removal, including at field boundaries. The consequences of this may include decreases in populations dependent on weedy species as trophic resources and selection for populations of weeds resistant to the molecule used. The case of varieties producing Bt toxins, which confers tolerance to some insect pests, has been the subject of numerous eco-toxicological studies and the interpretation of these results remains controversial. Finally, the possibility of the transfer of genes to other species in the field depends on the genetically modified species considered and its capacity to hybridise with wild species.

2.7 GAPS IN KNOWLEDGE ABOUT AGROBIODIVERSITY AND ITS DEPLETION

Studies of the effects of agriculture on biodiversity are numerous. However, it is apparent that few of these studies have developed generic hypothesis and theory capable of efficiently guiding public policy. There are certain reasons for this; these have been explained in the following sections.

The term biodiversity covers different biological components. The spatial scales and the levels of organization at which the effects of agriculture on biodiversity are considered, are numerous. While the theoretical frameworks exist, their capacity to structure current knowledge into general principles has rarely been tested, and they are rarely used. The ways in which agriculture, human stakeholders and their environmental interactions are taken into account is, rarely sufficient to lead to useable recommendations.

Current knowledge of the effects of agriculture on biodiversity is overwhelmingly from ecological or agroecological models and studies. Both stakeholders and socio-economic factors, despite the fact that they are often powerful drivers of biodiversity changes, are largely ignored in studies investigating the effects of agriculture on biodiversity. An understanding of sociological, economic, legal and technical processes, determinants and constraints associated to various stakeholders is desirable in order to fully appreciate dynamics of these changes.

Although there is an emerging consensus among civil society, the research community and policy makers that concrete steps must be taken to promote sustainable use of agrobiodiversity, scientific controversy remains over its meaning and how to achieve it. The International Treaty on Plant Genetic Resources for Food and Agriculture requires contracting parties to devise policy mechanisms and measures to support sustainable use. The Convention on Biological Diversity refers to use of the 'components' of biological diversity 'in a way and at a rate' that does not lead to a biodiversity decline.

Though intuitively appealing, this concept is far from operational. Biological diversity has many components whose interactions are still poorly understood; policies supporting the sustainable use of one component without full recognition of these interactions could have unintended consequences. There are at least two reasons why it is essential to integrate research about components of agrobiodiversity from a landscape or habitat perspective.

Without doubt, a holistic approach to valuing the components of agrobiodiversity will advance scientific knowledge. In addition, applied research that takes interactions among components into account could lead to estimates of costs and benefits that differ in important ways from those that do not. Ignoring interactions among components could bias policy recommendations. For example, many small-scale farmers address multiple objectives simultaneously, such as producing grains that provide food for humans and forage for animals. By doing so, they integrate the production of two or more agrobiodiversity components i.e. crops and livestock.

In intensive farming systems too, crop products serve as inputs for both livestock and fish production, and manure and animal power also serve as an input to crop production. Planted alongside crops or intermingled within fields, some tree species contribute to favourable growing conditions in addition to supplying primary products. Thus, economic policies and development interventions that affect one component often affect another, with implications for agrobiodiversity conservation. Such connections between agrobiodiversity components become even more complex when the scale of observation and analysis shifts from farm to landscape. Habitats, both agricultural and proximate to agricultural areas, serve as focal points where multiple components of biodiversity converge and interact. Researchers have recognized that some of the most significant forces driving change in diversity levels within components are also the same across components such as the processes of agricultural intensification and the spread of market infrastructure.

Check Your Progress 2

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) How does use of fertilizers affect agrobiodiversity?

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2) What are the major gaps in our understanding about agrobiodiversity loss?

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2.8 LET US SUM UP

- Agrobiodiversity loss chiefly comprises erosion of genetic diversity of crops, livestock and associated biodiversity.
- The loss of agrobiodiversity and the progressive homogenization of many ecosystems can be said as one of the main threats to the survival of our natural as well as socioeconomic systems.
- Since the 1900s, some 75 percent of plant genetic diversity has been lost as farmers worldwide have left their multiple local varieties and landraces for genetically uniform, high-yielding varieties.
- Of a total of 7616 livestock breeds studied by FAO, around 20 percent breeds are classified as at risk.
- The major factors leading to agrobiodiversity erosion are rapid expansion of industrial and green revolution, globalization of food system and marketing, replacement of traditional varieties by improved or exotic varieties and species, land clearing, overexploitation of species, population pressure, environmental degradation, overgrazing, and changing agricultural systems and policies.
- Agricultural intensification, and its corollary, the simplification of agricultural landscapes, are the major factors responsible for the loss and profound modification of biodiversity, in particular over the last few decades.

2.9 KEY WORDS

Millennium Ecosystem Assessment : A global project conducted by UNO under CBD framework to assess impact of changing ecosystems on human wellbeing.

Intensive agriculture : Agriculture which is based on the principle of high input and high output.

Genetic diversity : Diversity within a species due to variation in genetic make up.

Exotic varieties : Species that is not native of an area and is taken from outside region.

Organic agriculture : Agriculture based on use of biological resources as inputs.

2.10 REFERENCES AND SUGGESTED FURTHER READINGS

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- Kontoleon, Andreas, Pascual, Unai and Smale, Melinda (Editors) 2009. Agrobiodiversity conservation and economic development. Routledge, London and New York.

Relevant Websites:

- http://en.wikipedia.org/wiki/Agrobiodiversity
- http://www.cbd.int/agro.
- http://www.agrobiodiversity-diversitas.org/
- http://agrobiodiversityplatform.org/
- http://www.fao.org/biodiversity/en/

2.11 KEY TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Your answer must include the following points:
   - Relatively few varieties of crops or breeds of livestock are used
   - Intensive use of fertilizers which also reduce agrobiodiversity
2) Your answer must include the following points:
   - IPR and patenting has led to the widespread cultivation of fewer varieties and breeds
   - Marginalization of small-scale, diverse food production systems that conserve farmers' varieties of crops and breeds of domestic animals

Check Your Progress 2

1) Your answer must include the following points:
   - Fertilizer application has positive results on agrobiodiversity as long as this does not reach toxic levels
   - Fertilization results in disappearance of species adapted to low nutrient environments
2) Your answer must include the following points:
   - Human stakeholders and their environmental interactions are not adequately understood
   - Biological diversity has many components whose interactions are still poorly understood

UNIT 3 MANAGEMENT OF AGROBIODIVERSITY

Structure

3.0 INTRODUCTION

Agrobiodiversity or agricultural biodiversity encompasses the variety and variability of animals, plants and micro organisms which are necessary to sustain key functions of the agroecosystems, including the processes that support food production. In the past five decades, intensification and the homogenization of agroecosystems have led to significant losses in agrobiodiversity, including the loss of crop and livestock species, genetic diversity, as well as crop associated biodiversity. Erosion of agrobiodiversity has negative impacts on the long-term sustainability of agricultural systems and on food security, especially of poor populations living in marginal lands. There is growing consensus among citizens, scientists and policymakers that concrete steps must be taken at national, regional and international scales to support the conservation of biological diversity including agrobiodiversity. There is need to adopt new and more sustainable forms of agricultural production which can meet the changing social and environmental demands. In fact, conservation of agrobiodiversity is one prerequisite to achieve sustainability in agroecosystems.

The present unit gives an overview of different aspects of sustainable use of agrobiodiversity. Different issues related to sustainable use of plant and animal genetic resources and their implications on the food security and farmers livelihood have particularly been discussed. Legislative frameworks related to protection of plant varieties for fair and equitable sharing of benefits arising from commercial use of agrobiodiversity have been analyzed in global and Indian context. Role of community in agrobiodiversity conservation has also been highlighted.

3.1 OBJECTIVES

After reading this unit, you will be able to:

- explain the need of sustainable use of agrobiodiversity in agriculture;
- describe issues related to sustainable use of plant and animal genetic resources;
- underline the importance of farmers and community in agrobiodiversity management; and
- discuss the policy framework related to protection of plant genetic resources.

3.2 IMPACT OF CURRENT PATTERN OF AGRICULTURE ON AGROBIODIVERSITY

Over the past 50 years agriculture has been remarkably effective in increasing production to meet the demands of ever increasing populations. Much of the increase has come from intensification of production systems through increased input use. Adoption of improved crop varieties developed and disseminated by plant breeding programmes has also had a very important role to play. Studies show the strong impact of improved variety adoption on agricultural productivity growth as a result of international and national plant breeding efforts, particularly in Latin America, and more recently in the Middle East North African region.

While impressive, these accomplishments have come at a cost in terms of their environmental impacts, which affect both agricultural and nonagricultural sectors. The focus of efforts in the recent past to enhance the contribution of the use of plant genetic resources to agriculture has been on productivity rather than resilience (even though there has been substantial investment in breeding for resistance to biotic and abiotic stresses); broad scale adaptation rather than specific adaptation (both to markets and production environments); centralization of decision-making by plant breeders rather than farmers.

This approach has been successful in some areas, but not others. Studies made on eleven major food crops in past four decades, have shown that the contribution of modern varieties to productivity increases was a 'global success, but for a number of countries a local failure'. Key shortcomings cited have been the focus on varieties adapted for high potential production areas with the use of complementary inputs, which are not suitable for the variable, heterogeneous and marginal production areas found in many developing countries. Some approaches have worked against resilience, and thus long run average productivity. For example, plant breeding approaches that aimed at eliminating photoperiodism from millet and sorghum varieties in the Sahelien band of Africa made the agricultural systems less adapted to year-on-year climate variability.

Another criticism of centralized plant breeding programs has been the lack of farmer involvement and emphasis on widely adapted varieties, which limited attention to traits that are important to local farmers. On the environmental side, increases in pesticide and fertilizer use accompanying the high yielding varieties have generated serious damage to land and water, generating high economic costs which are only now becoming apparent.

Increasing consensus is being reached in the science, technical and policy fields that new and more sustainable forms of agricultural production are needed to meet the agricultural, social and environmental demands of society. Achieving these goals, however, involves much controversy and debate. The gap between expert driven technology development and local participatory approaches is one of the challenge. Another reason is the variability in the agro-ecosystems and socio-economic contexts under consideration as well as the type of change needed. Improving the access of poor farmers in marginal production environments, to the crop genetic resources and reducing the environmental damage associated with capital intensive production systems are two very different objectives that require two different strategies.

3.3 MANAGEMENT OF AGROBIODIVERSITY FOR ITS SUSTAINABLE USE

The Millennium Ecosystem Assessment concluded that human activities have led to a more rapid loss of biodiversity on Earth over the past 50 years than ever before in human history. The assessment argued that the loss of species and the progressive homogenization of many ecosystems continue to be one of the main threats to the survival of our natural as well as socio-economic systems. Intensification and the homogenization of agricultural eco-systems have led to significant losses in agrobiodiversity, including the loss of crop and livestock species and genetic diversity, as well as crop associated biodiversity such.

Without proper management of agricultural biodiversity some key functions of the agro ecosystem may be lost, such as maintenance of nutrient and water cycles, pest and disease regulation, pollination and hand erosion control. Erosion of agricultural biodiversity has negative impacts on the long term sustainability of agricultural systems and on food security, especially of poor populations living in marginal lands. Global environmental change and recognizable, irreversible loss of biodiversity have hastened a consensus among citizens, scientists and policymakers, that concrete steps must be taken at national, regional and international scales to support the conservation of biological diversity including agrobiodiversity.

Conservation of biodiversity has become a mainstream issue and not just confined to conservationists. Yet, despite scientific progress in understanding how to conserve genes and species, little is understood about interactions among components of biological diversity and ecosystem service provision in agricultural landscapes. The mechanisms and tools used for sustainable agricultural biodiversity management are quite distinct from those traditionally used for wild diversity conservation (such as protected areas). This is because agricultural biodiversity management involves necessary trade offs with human aspirations for improved food security and improved livelihoods. Setting aside lands for agricultural biodiversity conservation is generally not an option in developing societies with growing populations.

The recently released World Bank's World Development Report (2008) makes a very strong case for agricultural development as the primary pathway out of poverty for the developing world, particularly for countries in Sub Saharan Africa, that are still in the early stages of the structural transformation process. For these societies, agricultural biodiversity management has to be seen as an integral part of the overall strategy for agricultural and economic development. We will have to find ways to develop agriculture to improve food security and reduce poverty while at the same time protecting agricultural biodiversity.

Article-2 of the Convention on Biological Diversity defines sustainable use of biodiversity in general as the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, there by maintaining its potential to meet the needs and aspirations of present and future generations. Sustainable use of plant genetic resources, a major component of agricultural biodiversity, is a primary objective of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) which came into force in 2005. Plant genetic resources for food and agriculture are defined as any genetic material of plant origin of actual or potential value for food and agriculture. Article-6 of the ITPGRFA requires contracting parties to develop and maintain appropriate policy and legal measures that promote the sustainable use of plant genetic resources for food and agriculture.

No concise definition of sustainable use is provided, although several examples of measures to achieve sustainable use are given, including: broadening the genetic base of crops, increasing the range of genetic diversity available to farmers, promoting plant breeding efforts to develop varieties that are well adapted to the situation of farmers, particularly in marginal areas, and supporting the use of more diverse crop varieties. Cultivation of more diverse local varieties reduces the vulnerability of the crop to epidemics of plant disease and pests, and protects against genetic erosion. These approaches aim to increase world food production in ways that are compatible with sustainable development.

3.4 MANAGING AGROBIODIVERSITY FOR FOOD AND AGRICULTURE

Managing plant genetic resources for sustainable use in food and agriculture is a current and pressing policy objective from the standpoints of supporting productivity, reducing poverty and protecting the environment. Agriculture faces several challenges: the sector is under pressure not only to produce agricultural goods for rapidly growing populations, but also to meet food and livelihood security for large numbers of rural poor, while reducing negative impacts on the environment. Climate change exacerbates these challenges, requiring that agricultural systems adapt in order to sustain, let alone increase, production. Some of the necessary responses to climate change will place additional burdens on agriculture, whether through the demand for biofuels or the need to maintain carbon sinks by reducing the amount of land made available for agriculture. A number of reports published recently highlighted these pressures and expectations. For example, the 2008 World Bank Development Report highlights the role of agriculture in contributing to social and economic development, identifying its key role in poverty reduction in agricultural based economies. The International Assessment of Agricultural Science and Technology (IAASTD) 2008, reflected the importance of agricultural science and technology.

The Millennium Ecosystem Assessment and the Global Biodiversity Outlook noted that agriculture is the largest driver of biodiversity loss, through land use change, water and nutrient use. At the same time the decline in most ecosystem services, risks undermining agricultural productivity. These reports provide varying perspectives and depart from different underlying paradigms. These differences are both worrying and refreshing, and they are manifested in much of the discussion around sustainable use of plant genetic resources for food and agriculture (PGRFA).

The sustainable use of genetic resources can be broadly defined as the use of genetic resources in support of sustainable agriculture, which requires a system of agriculture that produces and facilitates access to sufficient food for all people and contributes to livelihoods and socio-economic development, while protecting the environment. Sustainable agriculture must be productive, indeed, in many cases, more productive than it currently is, to deliver the food, feed, fibre that are required, and also to generate the economic surpluses needed to support livelihoods, create employment and power economic development. Sustainable agriculture must also be resilient – and here again an increase over current levels is needed, in order to cope with the changes confronting the sector. Finally, sustainable agriculture must be conserving of natural resources, in order to maintain productivity and resilience in the future. The deployment of genetic resources at genetic and species levels, and at the level of the agro ecosystem and landscape, plays a crucial role in contributing to increases in productivity and resilience and conservation. In turn, these are influenced by policies, research and plant breeding, and capacity building.

3.5 AGROBIODIVERSITY CONSERVATION IN AGRICULTURE BASED ECONOMIES

Typologies of countries have been developed in order to discuss strategies for sustainable agricultural development. For example, the World Development Report (2008) groups countries into agricultural based, transforming and urbanized economies, according to the importance of agriculture in the overall economy. In agricultural based economies, which include most of Sub Saharan Africa, increasing the productivity of smallholder farming is a necessary prerequisite to generating economic growth, and reducing poverty and food insecurity. More emphasis should be given to client driven participatory research that incorporates a wide range of stakeholders across multiple scales.

SubSaharan Africa typifies examples of agricultural based economies. In much of the region, farmers are producing on marginal lands, with limited market access and exposed to high levels of risk from climatic variability, invasions of plant pests and epidemics of plant disease. Crop production is focused on food crops for consumption by farm households. Agricultural productivity is low and agricultural input and output markets are not well developed. Most farmers currently rely upon landraces for their crop production, although in some areas, improved varieties from conventional breeding programmes have been widely adopted for a few crops. At present, the use of genetically modified varieties is very limited. Diversified farming systems and the use of low productivity, low risk crops and varieties are key strategies these farmers employ to manage the risks they face.

Improving productivity and profitability in smallholder agricultural systems, while maintaining or increasing the resilience of such systems, is essential to attain sustainable use for the region. Specifically, increasing agricultural productivity and stability, as well as net returns to marketed surpluses from farming is needed. A wide range of crop genetic resources are needed to meet these goals across the heterogeneity of production systems and agroecological conditions that are found in agricultural based economies.

In situ on farm genetic resource management programmes also have significant potential to improve the livelihoods of farmers at the local level. Onfarm conservation and use programmes can be combined with local infrastructure development or the increased access for farmers to useful germplasm held in national genebanks. Farmers benefit from the continued agricultural diversity and ecosystem health that these programmes support. Local crop resources can be the basis for initiatives to increase crop production or secure new marketing opportunities. By building development efforts on local resources and through the empowerment of farming communities, they can lead to sustainable livelihood improvement. Resource poor farmers, in particular, may benefit if development initiatives are not based on external inputs, that may be costly or inappropriate for marginal agroecosystems.

On farm conservation and use also serves to empower farmers to control the genetic resources in their fields. On farm genetic resource management recognizes farmers and communities as the curators of local biodiversity and the traditional knowledge to which it is linked. In turn, farmers are more likely to reap any benefits that arise from the genetic material they are managing.

3.6 INTEGRATING FARMERS INTO AGROBIODIVERSITY CONSERVATION

Farmers are likely to know the nature and extent of local crop resources better than anyone, through their daily interactions with the diversity in their fields. Given their expertise, incorporation of farmers into the national genetic resources system can help create productive partnerships for all involved. This integration can happen in several ways, including seeing farmers as partners in the maintenance of selected germplasm; establishing a national dialogue on biodiversity conservation, sustainable use and equitable benefit-sharing between farmers, genebanks and other partners; assisting the exchange of information with and among farmers from different sites and projects; farmers visiting genebanks or seeing demonstrations by genebanks; developing systems to make genebank material more easily accessible to farmers.

Farmers 'use' crop genetic resources through their selection of the crops and varieties they plant. Their decisions are driven by both supply and demand factors: e.g., the crops and varieties that meet their specific production, marketing and consumption requirements and those that are accessible to them. Both the supply of, and demand for, genetic resources are affected by policies and regulations. For example, the demand for crop varieties is linked to the development of output markets, while the supply of genetic resources is affected by policies governing plant breeding and seed sector regulations.

Farmers choices of crops and varieties can then be thought of as a constrained optimization; farmers choose the best combination to meet their needs given agro ecological and social constraints, including those imposed by policies. Their choices can also potentially affect others in the form of externalities. From the literature, the benefits created by farmers' use of crop genetic resources can be grouped into three main categories: (i) Private benefits to farmers via the consumption and production values they derive from producing crops, which are shaped by policies affecting the demand and supply of crop genetic resources. (ii) Local or regional benefits to farmers, and ultimately, consumers, when the choices make farming more resilient to biotic and abiotic stresses. (iii) Global benefits to future farmers, plant breeders and consumers, when the choices they make protect against genetic erosion. Will the choices farmers make for their own private benefit also provide the local and global public goods of resilience and conservation? Experience over the course of this century, indicates that conflicts may indeed exist: specialization of crops and varieties on farm can generate high private benefits to farmers but reduce local resilience; on farm conservation of globally important genetic resources may reduce farm profits.

As far as farmers participation in agrobiodiversity management is concerned, farmers access to plant genetic resources is also important. This includes the availability of the resource as well as the ability of the farmer to acquire it by having information and resources to purchase it or obtain it by other means. Here again, the situation is characterized by a great deal of heterogeneity, with a few general principles. On farm saved seed is generally the form of seed and crop genetic resources, that is most easily accessed by farmers. Seeds of these varieties are also procured through informal exchange mechanisms which vary in their rules of exchange, based on social norms. They are increasingly found in local markets where they are obtained by farmers via purchases, which also vary in terms of rules of exchange and are affected by social norms as well as market forces. Aside from these informal seed sector sources, farmers may also purchase seed of improved and certified varieties produced by publicly or by privately funded breeding programmes and distributed through government sponsored organizations or private companies and traders. Across most of Sub-Saharan Africa, however, the development of commercial seed systems has been generally slow and in most countries significant for only a small number of mostly high value crops.

The seeds may come through formal and informal systems, and may contain new combinations of genes that result from hybridization and introgression between wild and cultivated plants or among cultivated varieties. Whether new combinations of genes or new seed types are maintained, with the resultant development of populations with new characteristics depends on farmer management and access. Rather than being passive recipients of seed from the formal sector (government, extension agencies, seed companies), farmers participate in dynamic networks of seed exchange and development.

Farmers shape the degree and distribution of genetic diversity in their crops both directly, through selection, and indirectly, through management of different agroecosystem components. For many farmers in developing countries, the availability of adaptive varieties for particular microniches may be one of the few resources available to increase or maintain production on his or her field.

3.7 MANAGEMENT OF ANIMAL GENETIC DIVERSITY

Thousands of years of animal husbandry and controlled breeding, combined with the effects of natural selection, have given rise to great genetic diversity among the world's livestock populations. High output animals intensively bred to supply uniform products under controlled management conditions, coexist with the multipurpose breeds kept by small scale farmers and herders mainly in low external input production systems. Effective management of animal genetic diversity is essential to global food security, sustainable development and the livelihoods of hundreds of millions of people. The livestock sector and the international community are facing many challenges. The rapidly rising demand for livestock products in many parts of the developing world, emerging animal diseases, climate change and global targets such as the Millennium Development Goals need to be urgently addressed. Many breeds have unique characteristics or combinations of characteristics i.e. disease resistance, tolerance of climatic extremes or supply of specialized products that could contribute to meeting these challenges. However, evidence suggests that there is ongoing and probably accelerating erosion of the genetic resource base.

Effective management of animal genetic diversity requires well trained man power, adequate technical facilities, sound organizational structures, wide stakeholder (particularly breeders and livestock keepers) involvement in planning and decision making. Unfortunately, these prerequisites are largely lacking in most of the developing countries. 48% of the world's countries report no national level *in vivo* conservation programmes, and 63% report that they have no *in vitro* programmes. Similarly, in many countries structured breeding programmes are absent or ineffective.

In a time of rapid change and widespread privatization, national planning is needed to ensure the long term supply of public goods. Livestock sector development policies should support equity objectives for rural populations so that these populations are able to build up, in a sustainable way, the productive capacity required to enhance their livelihoods and supply the goods and services needed by the wider society. The management of animal genetic resources needs to be balanced with other goals within the broader rural and agricultural development framework. Careful attention must be paid to the roles, functions and values of local breeds and to how they can contribute to development objectives.

On the basis of evidences of historic gene flows and current patterns of livestock distribution, it can be said that the countries and regions of the world are interdependent in the utilization of animal genetic resources. In the future, genetic resources from any part of the world may prove vital to breeders and livestock keepers elsewhere. There is a need for the international community to accept responsibility for the management of these shared resources. Support for developing countries and countries with economies in transition to characterize, conserve and utilize their livestock breeds may be necessary. Wide access to animal genetic resources for farmers, herders, breeders and researchers is essential to sustainable use and development. Frameworks for wide access, and for equitable sharing of the benefits derived from the use of animal genetic resources, need to be put in place at both national and international levels. It is important that the distinct characteristics of agricultural biodiversity, created largely through human intervention and requiring continuous active human management are taken into account in the development of such frameworks.

International cooperation, and better integration of animal genetic resources management into all aspects of livestock development, will help to ensure that the world's wealth of livestock biodiversity is suitably used and developed for food and agriculture, and remains available for future generations.

Fig. 3.1: Assessing Biodiversity of Animal Genetic Resources

Source: http://www.gifu-u.ac.jp/~tadano/research-e.html

Check Your Progress 1

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) How does agricultural intensification lead to agrobiodiversity erosion?

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2) Why should farmers be incorporated in agrobiodiversity management?

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3.8 POLICY FRAMEWORK FOR AGROBIODIVERSITY CONSERVATION: INTERNATIONAL LEVEL

We know that at international level, the Convention on Biological Diversity 1992 (CBD) is the first global agreement on the conservation and sustainable use of biological diversity. CBD gained rapid and widespread acceptance. Presently, more than 193 countries have ratified the agreement. As discussed in previous chapters the Convention on Biological Diversity has three main objectives or goals: Conservation of biodiversity, sustainable use of the components of biodiversity, and sharing of benefits arising from the commercial and other utilization of genetic resources in a fair and equitable way. CBD and other global conventions related to biodiversity assessment and conservation have already been described in another block (Ecosystem and Biodiversity).

In 2010, at the tenth meeting of Conference of the Parties to the Convention on Biological Diversity in Nagoya, Japan, the Nagoya Protocol was adopted. Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity is an international agreement, which aims at sharing the benefits arising from the utilization of genetic resources in a fair and equitable way, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding, thereby contributing to the conservation of biological diversity and the sustainable use of its components.

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), popularly known as the International Seed Treaty, is another comprehensive international agreement, in harmony with the Convention on Biological Diversity, which aims at food security through the conservation, exchange and sustainable use of the world's plant genetic resources for food and agriculture (PGRFA), as well as the fair and equitable benefit sharing arising from its use. It also recognises Farmers' Rights: to freely access genetic resources, unrestricted by intellectual property rights; to be involved in relevant policy discussions and decision making; and to use, save, sell and exchange seeds, subject to national laws. The treaty has implemented a Multilateral System (MLS) of access and benefit sharing, among those countries that ratify the treaty, for a list of 64 of some of the most important food and forage crops essential for food security and interdependence.

3.9 POLICY AND INSTITUTIONAL FRAMEWORK FOR AGROBIODIVERSITY CONSERVATION IN INDIA

India has been a signatory to the Convention since 18th February, 1994, and is one of the first countries to have enacted an appropriate comprehensive legislation to achieve the objectives of the convention. As of now, 193 countries are party to the CBD. India has hosted COP-11 in 2012, in Hyderabad. We know that the COP-11 was significant as it marked the 10th anniversary of Johannesburg World Summit on Sustainable Development, 20th anniversary of the Rio Earth Summit and 40th anniversary of Stockholm Conference. During 2010, several activities have been organized to mark the celebration of International Year of Biodiversity.

India is committed to conservation of biodiversity including agrobiodiversity. This is not only because of India's International obligations as a signatory to the Convention on Biological Diversity, but because India believes that protecting our biodiversity is a critical national priority, as it is linked to local livelihoods of millions of people in the country. Sustainable use of our biodiversity, therefore, has both ecological and economic value. It is with this objective that India has enacted Biological Diversity Act, 2002 and set up a National Biodiversity Authority (NBA) in 2003 with an explicit mandate of promoting conservation of biological resources and associated knowledge as well as facilitating access to them in a sustainable manner.

The Biological Diversity Act, 2002, passed on December 11, 2002 came into force on February 5, 2003, followed by the formation of it Rules in 2004. The Biological Diversity Act of 2002, provides necessary statutory and administrative mechanism at the National, State and Local body levels to realize the objectives of the Act as well as of CBD. A three-tiered system of regulation is envisaged under the Biological Diversity Act, which consists of the National Biodiversity Authority (NBA) at the apex level, Biodiversity Boards (SBBs) at State level and Biodiversity Management Committees (BMCs) at local level.

Section 37, of the Biological Diversity Act (BDA), 2002 deals with identification of Biodiversity Heritage Sites in the country. The State Governments in consultation with local bodies are supposed to notify the important areas of biodiversity as Biodiversity Heritage Sites. Further, notification, and framing of rules for managing and conserving biodiversity heritage sites have to be harmonized with the Protection of Plant Varieties and Farmers' Rights Act, 2001, that has a provision for utilization of a Gene Fund, particularly in areas identified as agrobiodiversity hot spots according to Rule 70(2)2. However, approaches for identification and conservation are lacking and therefore, there is a need to develop indices for identification of this valuable component of biodiversity, important for food, fodder and nutritional security. In addition to identification, there is a need for their characterization and value assessment to facilitate their promotion and use in evolving sustainable agriculture.

India has large number of scientific personnel and important network of scientific institutions in public, private and NGOs sectors that are playing significant role in assessment and conservation of biodiversity including agrobiodiversity of the country. The important institutions/ organizations include Indian Council of Agricultural Research, Botanical Survey of India, Zoological Survey of India, Wildlife Institutes, Fishery Survey of India, Forest Survey of India, Council of Scientific and Industrial Research, Department of Biotechnology, Department of Science & Technology etc. As discussed in previous units National Bureaus on plants, animals, fish, insects, microbes and forest genetic resources are specifically mandated for management of genetic resources. In addition to this all India Coordinated Project on Taxonomy and network projects on honeybee and pollinators and ornithology are also in place for capacity building and research.

The Indian Council of Agricultural Research (ICAR) is an autonomous organisation under the Department of Agricultural Research and Education

(DARE), Ministry of Agriculture, Government of India. The Council is the apex body for coordinating, guiding and managing research and education in agriculture including horticulture, fisheries and animal sciences in the entire country. With 99 ICAR institutes and 53 agricultural universities spread across the country, this is one of the largest national agricultural systems in the world. Under the aegis of ICAR, five bureaus are working in different aspects of agrobiodiversity. These are on plant genetic resources, animal genetic resources, fish genetic resources, agriculturally important micro organisms and agriculturally important insects. Renowned agricultural scientist, Prof. M.S. Swaminathan has strongly proposed to bring all bureau on a single platform for effective management of agrobiodiversity in the country. He also emphasized the need of strengthening the infrastructure of ICAR and suggested establishment of gene cum seed bank in all the 128 agro climatic zones of the country.

The Indian National Gene Bank is established by the Indian Council of Agricultural Research (ICAR) as a part of the National Bureau of Plant Genetic Resources (NBPGR). It has conserved more than 150,000 accessions and samples. The capacity of this gene bank has been increased to about 1 million making it the largest gene bank of the world. It has more than 7100 accessions of underutilized crops. A range of crops like millets, oil seeds, vegetables, pulses and narcotics have been maintained for several years in liquid nitrogen without any decline in viability. In recent years, several organizations collectively called Non-Governmental Organizations (NGOs), 'Seed Savers Exchange', and industries (e.g. community and regional seed banks or gene bank) have emerged to support and expand local efforts on global biodiversity conservation. In many cases, they link traditional farmers with *exsitu* conservation programmes. "Seed Savers Exchange" conserves and exchanges over 5000 native varieties. *Exsitu* conservation of crops like sugarcane, rubber, oil palm, pineapple, etc. is also done by industries. Farmers also help in ex-situ conservation of forest trees and fruit trees through practice of agroforestry, which is facilitated and encouraged by ICRAF (International Centre for Research on Agroforestry). In order to honor the farmers who have conserved the germplasm of crop plants, the Genome Savior Award has also been set up by the Indian government.

To ensure the fair and equitable sharing of benefits arising out of the use of genetic resources, India has taken significant legislative measures and also integrated these principles in various policies and programmes. The Protection of Plant Varieties and Farmer's Rights Act, 2001 and Rules, 2003 deal primarily with the protection of plant breeders rights over the new varieties developed. The second and third amendments to the Patent Act, 1970 provide for mandatory disclosure in the patent application, of the source and geographical origin of the biological material used in the invention. National Innovation Foundation (NIF), an autonomous society established in 2000, for recognizing, respecting and rewarding innovations and outstanding traditional knowledge at grassroot level.

India has rich traditional knowledge about medicinal values of plants and natural products which have been used by people here since times immemorial. Documentation of this existing knowledge, available in public domain, on various traditional systems of medicine has become imperative to safeguard the sovereignty of this traditional knowledge and to protect it from being misappropriated in the form of patents on non-original innovations, and which has been a matter of national concern. In 1999, the Department of Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homoeopathy (AYUSH) and Council of Scientific and Industrial Research (CSIR) constituted an interdisciplinary Task Force, for creating an approach paper on establishing a Traditional Knowledge Digital Library (TKDL). TKDL is an effective deterrent to bio-piracy. India has also set up a global biopiracy watch system under TKDL in respect of patent applications related to Indian System of Medicines.

3.10 COMMUNITY BASED AGROBIODIVERSITY CONSERVATION: CONTRIBUTION BY MSSRF

The importance of community based on farm conservation, in imparting dynamism to the genetic resource variability and ecosystem services is recognized by several case studies. Agrobiodiversity is often closely linked with the rural life, livelihood and the cultural ethos of the communities across the world. Many rural communities including over 550 tribal groups living in diverse agroecological regions of India have been conserving and enriching genetic resources of many crops to meet their nutritional, health and livelihood security along with ecological security. Such onfarm conservation is assuring higher importance in the context of global climate change.

M. S. Swaminathan Research Foundation (MSSRF), since its inception, 25 years back, has been undertaking and advocating agrobiodiversity conservation with emphasis on community participatory on-farm approach along with *ex situ* conservation. This work has been focusing at three important agrobiodiversity rich Eastern and Western Ghats in India. These are the Jeypore tract of Orissa, Kolli Hills of Tamil Nadu and the Wayanad in Kerala. Jeypore tract is known as the major centre of rice genetic diversity. Kolli Hills is notable for small diversity. Wayanad has large medicinal plant diversity. The first two locations fall within the Eastern Ghats and the last within the Western Ghats.

In India, the *in situ* and *ex situ* systems of consvation have conventionally been studied and regulated from the point of view of scientists and foresters. In order to promote the role of local communities in *in situ* on-farm conservation of agrobiodiversity, the MSSRF has set up a Community Agrobiodiversity Centre (CAbC) at Kalpetta, Wayanad. These regions have larger tribal population engaged in traditional conservation and is also known for the wealth of traditional knowledge for example special rice varieties like Njavara, which are used in Ayurveda, a popular Indian traditional medicine.

While the MSSRF work on onfarm conservation was started in 1989, the *ex situ* conservation was added since 1994, with the establishment of the Community Gene Bank under GT. Scarascia Mugnozza Community Genetic Resource Centre (SMCGRC). The SMCGRC follows integrated conservation with on-farm and *ex situ* Community Gene Bank (CGB) activities as well as empowerment of rural youths, school children and rural women and men in documenting and conserving local agrobiodiversity using field level with the help of agrobiodiversity Conservation Corps (ABCC), school level Genome Clubs (GC), and village level Gene-Seed-Grain Banks (GSGB) in hub and spokes model. The CGB also imparts them legal and genetic literacy associated with conservation, access and benefit sharing.

3.11 SCIENTIFIC DEVELOPMENTS AND STRATEGIES FOR AGROBIODIVERSITY CONSERVATION

A number of recent developments in biodiversity sciences are expected to provide solution to check current pattern of agrobiodiversity loss and ways to conserve it. For examples, the genomic structure for several major crop species and their wild relatives is now being described, and this provides a wealth of information and analyses that can be used for describing biodiversity at the genetic level and its use in crop production. Recent agronomic research has emphasized systems analysis to show the benefits of biodiversity based practices such as cover crops, intercrops, rotations, and hedgerows for agricultural productivity and environmental quality.

Ecological research has shown that greater numbers of species result in higher productivity of grassland ecosystems, which is relevant not only for pastures, but for other types of agriculture. Using satellite imaging systems, the distribution of ecosystems in agricultural landscapes can now be described with high resolution, yielding information on how to better manage agricultural species, invasive, and wild species. New efforts to merge biological and economic approaches are generating information on how policies can affect the conservation and use of agrobiodiversity for enhancement of human wellbeing.

Attempts should be made to maximise agrobiodiversity while keeping costs as low as possible. This requires an approach that goes far beyond the conservation strategies most widely used today. The *ex situ* conservation of seeds, involving storage in refrigerated banks or botanical gardens, is essential but does not go nearly far enough. What is needed are broader and better integrated conservation schemes that rely primarily on in situ concepts the conservation and breeding of genetic resources by farmers and farming communities on their farms and in their villages. Farmers have been doing this for thousands of years. Gene banks can complement their work but cannot replace it. *In situ* schemes enable the use and conservation of genetic resources to be closely linked. True to the slogan "use it or lose it", plant species or animal breeds should be used whenever and wherever possible; they should contribute to securing rural livelihoods and form a part of rural culture.

Check Your Progress 2

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) Write names of the major policy framework at international level for assuring sustainable use of agrobiodiversity.

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2) Write names of any two scientific techniques which can help in agrobiodiversity management and conservation.

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3.12 LET US SUM UP

- In the past five decades, intensification and the homogenization of agroecosystems have led to significant losses in agrobiodiversity.
- There is growing consensus worldwide that concrete steps must be taken to support the conservation of biological diversity including agrobiodiversity.
- In less industrialized countries, agrobiodiversity management is the primary pathway out of poverty and hunger and it can be seen as an integral part of the overall strategy for agricultural and economic development.
- Integration of farmers in overall agrobiodiversity management is one of the potential options towards sustainable use of crop genetic resource, conservation of rich diversity of germplasm and equitable sharing of benefits.
- At international level, Nagoya Protocol under CBD and ITPGRFA play key role in facilitating sustainable use of agrobiodiversity.
- India has been a signatory to the Convention since 1994, and is one of the first countries to have enacted an appropriate comprehensive legislation to achieve the objectives of the convention.
- The importance of community based on-farm conservation in imparting dynamism to the genetic resource variability and ecosystem services is recognized by several case-studies.

3.13 KEY WORDS

Millennium Ecosystem Assessment : A global project conducted by UNO under CBD framework to assess impact of changingecosystems on human wellbeing.

Germplasm : Genetic material (DNA) of a particular variety or species of plant or animal; often used in context of its preservation.

Genebanks : Storage of genetic material (DNA) of different plant or animal species which often serves the purpose of ex-situ conservation.

In situ conservation : Conservation of biological diversity in their natural habitats.

Ex situ conservation : Conservation of biodiversity at place away from their natural habitat.

Resilience : Capacity of ecosystems to restore its optimal state after varying degrees of disturbances.

3.14 REFERENCES AND SUGGESTED FURTHER READINGS

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- http://en.wikipedia.org/wiki/Agrobiodiversity
- http://www.cbd.int/agro/
- http://www.diverseeds.eu/ (Networking on conservation and sustainable use of plant genetic resources in Europe and Asia)
- http://en.wikipedia.org/wiki/International_Treaty_on_Plant_Genetic_Resources_for_Food_and_Agriculture
- http://www.icar.org.in/node/1333
- http://www.globalplanofaction.org/index_en.jsp
- http://www.agrobiodiversity-diversitas.org/
- http://agrobiodiversityplatform.org/
- http://www.fao.org/biodiversity/en/

  http://www.NSSrf.org

3.15 KEY TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Your answer must include the following points:
   - Lesser number of crop species are grown for commercial scale production
   - Hybrid varieties replace traditional varieties of crops

2) Your answer must include the following points:
   - Farmers know about his crops better than anybody else
   - Farmers are the custodians of rich genetic resources of traditional varieties

Check Your Progress 2

1) Your answer must include the following points:
   - Nagoya Protocol under CBD
   - ITPGRFA
2) Your answer must include the following points
   - Remote sensing techniques for agro-ecological management
   - Genome projects which can help in reconstruction of genetic information of the lost species

UNIT 4 PROMOTING GENETIC DIVERSITY: CHALLENGES AND OPPORTUNITIES

Structure

4.0 INTRODUCTION

Today's development and agriculture policies confront a difficult challenge to meet the demands of over 6.5 billion people around the world which is projected to grow to 9-10 billion by 2050. This implies that in order to meet the increased demand for food and fibre, more land would be converted to agriculture, and agricultural intensification would continue. This process is placing growing pressure on agricultural landscapes, thereby leading to unprecedented loss of agrobiodiversity and its services. The continued integration of international agricultural markets and the pressure from the agribusiness sector to shape agricultural landscapes into a more simplified and apparently manageable sector are also emerging as potential threat to agrobiodiversity. Associated to these challenges, there are opportunities which have potential to manage rich agrobiodiversity in agroecosystems. Recognition of traditional knowledge, participation of farmers in crop breeding programs, provision of gender sensitive policies and adoption of modern innovations are some of the potential options.

The present unit makes an attempt to analyze the implications of current global pattern of development on agrobiodiversity. While the previous three Units of the block have given a systematic account of introduction, depletion and conservation of agrobiodiversity, the present unit tries to analyze the complex socio-economic issues and identifies major challenges and opportunities which have potential role to decide the future scenario of agrobiodiversity. The main focus of the unit, however, remains to explore the alternative ways towards sustainable management of agrobiodiversity.

4.1 OBJECTIVES

After reading this unit, you will be able to:

- describe the implication of economic development on agrobiodiversity;
- explain the impact of genetically engineered crops on agrobiodiversity; and
- recognize the significance of women, traditional knowledge and participatory breeding for agrobiodiversity conservation.

4.2 CURRENT PATTERN OF ECONOMIC DEVELOPMENT AND AGROBIODIVERSITY

Present human society is living in the age of rapid ecological, social and economic changes, and the pace of this change will accelerate during the next several decades. The world's population of 6.5 billion people is projected to grow to 7.5 billion by the year 2020 and to 9-10 billion by 2050. By 2050, food consumption must double to meet human needs. To meet this increasing demand for food and fibre, production systems are expected to become increasingly dependent on inputs of fertilizers, pesticides and water and this imply that more land would be converted to agriculture, and agricultural intensification would continue. Irrigated lands will likely to increase by 1.9 fold by 2050. Pasture lands are also increasing, with an expected doubling in area by 2050. In 50 years, global agricultural land area is projected to increase by 18%, with a loss of 10^9 hectares of natural ecosystems.

This process is placing growing pressure on agricultural landscapes, thereby promoting species extinction in managed and constricted wild land habitats. Abandonment of already degraded fragile lands and agricultural encroachment on forest margins would most likely increase, with further loss of agrobiodiversity and its services. Added to this is the continued integration of international agricultural markets and pressure from the agribusiness sector to shape agricultural landscapes to a more simplified and thus apparently manageable sector, at an ever accelerating pace, especially in developing countries.

Simplifying agrobiodiversity translates in to disinvesting in natural capital and thus increasing the risks of already volatile agricultural commodity markets. Industrial countries with a highly developed financial sector may be able to substitute natural for financial capital to some extent. By contrast, in developing economies, when such financial markets exist, they are often rudimentary and incapable of insuring farmers against 'simplifying' choices. Managing a portfolio of capital without proper insurance mechanisms and well functioning markets is therefore a risky business.

Genetic vulnerability of our agroecosystems is one important aspect of our economic development. Such genetic vulnerability of today's global agricultural systems arises from a common dependence on relatively few crops and varieties. Each year, crop damage penalizes farmers in many of the world's villages, and for farmers who depend on their crops for their livelihoods, these penalties can be dire such as liquidation of assets, migration, and under nutrition. In intensive production systems, both the incidence of pests and plant diseases, and the potential for a large scale epidemic, are higher. Combating plant disease epidemics incurs costs for nations already strapped for funds, and these can involve unsafe use of chemicals. Coping with persistent crop damage and avoiding disastrous epidemics through maintenance breeding instead of chemical control requires long-term investments and access to a steady supply of diverse genetic resources.

Small scale farmers in developing countries are facing serious economic dilemma. For them the most profitable decision in agriculture is frequently to grow only a few crop varieties, and not to invest in conservation of the varieties that are less favoured by the market. In the case of genetic diversity, farmers who maintain *in situ* crop genetic diversity are essentially conserving a global public good and thus they can be seen as net subsidizers of modern agriculture and food consumers worldwide. However, global institutions are not in place to provide compensation for generating such global benefits. The net result is that global crop genetic diversity is rapidly being reduced, since the custodians of the global genetic portfolio are not compensated by current international markets, and there are no corrective policies or mechanisms in place.

4.3 TRANSITION FROM TRADITIONAL TO INTENSIVE AGRICULTURE

Nearly half of the world's population lives in rural areas and depends directly on agricultural systems. It is estimated that about 60% of the world's agriculture consists of traditional subsistence farming systems, in which there is a high diversity of crops and species grown and such as polycropping and intercropping. These systems encompass an enormous amount of the planet's agrobiodiversity, yet much of it has not been well documented in terms of species composition or function.

Modernization of agriculture is due to many factors including rapid population growth, breakdown of traditional institutions, and stronger market forces, exacerbated by the role of agribusiness and international trade pressures. An immediate effort must be made to conserve the biodiversity and human knowledge from traditional agroecosystems, so that it is available for solving agricultural problems, now and in the future, and to support human societies that rely on its cultural services.

Agricultural intensification and expansion of agriculture adversely impacts the biodiversity on and off-farm, thereby promoting species extinction in managed and constricted wild land habitats. Abandonment of degraded lands, desertification, and agricultural encroachment on forest margins will increase, with further loss of biodiversity and its services. Agricultural intensification, as defined here, refers to the use of nonrenewable, purchased inputs, such as pesticides and fertilizers, substitution of mechanization and fossil fuels for human labor, and high capital invested per unit of land.

Modern agriculture is currently one of the greatest extinction threats to biodiversity in both agroecosystems and in wildlands. Ironically, since the advent of agriculture, biodiversity has provided the raw material for new innovations in agriculture, critical ecosystem services, and options for an uncertain future. Yet at this time in human history, we face the prospect of agricultural landscapes that are biodiversity poor, with increasing threats to wild biodiversity. Humanity faces a challenge of meeting its growing needs for food and fiber from a resource that it is threatening to destroy.

4.4 SUSTAINABLE AGRICULTURE AND ROLE OF AGROBIODIVERSITY

To combat the adverse impacts of agricultural intensification and expansion, a transition has been set into motion worldwide toward sustainable agriculture, which is one that "will over the long term: satisfy human food and fiber needs, enhance environmental quality and the natural resource base upon which the agricultural economy depends, make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls, sustain the economic viability of farm operations, enhance the quality of life for farmers and society as a whole.

Biologically, there is much potential for increasing the utilization of agrobiodiversity for sustainable agriculture. The agricultural sciences have shown for decades that plant breeding can introduce genes to increase the quality of agricultural production, though recent advances with genetically modified organisms are very controversial. Crop diversity can clearly enhance nutrient use efficiency, and a diverse soil community may govern tighter nutrient cycling, control pests and diseases and improve soil structure. Ecological research has shown that biodiversity can increase the productivity of ecosystems. The structure of agricultural landscapes, i.e. mosaics of agricultural and nonagricultural ecosystems, now is recognized as important for the utilization and conservation of both on farm and off farm biodiversity.

Research that integrates the natural and social sciences is needed to explore the importance of agrobiodiversity for sustainable agriculture, its services, and the socioeconomic trade offs involved in its use and conservation. The challenge is to find ways to meet our immediate needs for food, fuel, and fiber while conserving sufficient biodiversity to assure our capacity to respond to climate and other anthropogenic environmental change. Moreover, to alleviate poverty in a rapidly growing world population using a finite set of rapidly eroding biological assets, we need to be able to identify the trade offs involved in alternative land uses much more effectively than has been done in the past. This requires a scientific approach that is driven by human needs, recognizes the interdependence between human behavior and ecosystem processes, and delivers a deeper understanding of the role of biodiversity in satisfying those needs.

4.5 INTEGRATION OF ECOLOGIC AND ECONOMIC PERSPECTIVE ABOUT AGROBIODIVERSITY

For an economist, agrobiodiversity is part of natural capital, and the flow of services that it provides is the 'interest' on this capital. Just as investors choose a portfolio of produced capital to maintain the return on capital over a range of market risks, so society needs to choose the mix of genes, species, communities, and ecosystems to maintain the flow of ecosystem services over a range of environmental and social risks. In order to design agricultural, development and conservation policies that maintain an ecologically acceptable and economically optimal level of biological diversity in agricultural landscapes, an understanding of the risk implications of changes in the mix is required. Economics can offer insights for decision makers by identifying the 'social opportunity costs' that result from agrobiodiversity loss. Such opportunity costs have to do with complex trade off among food production, biodiversity conservation, ecosystem services and human wellbeing.

Economists have shown, how investment in agrobiodiversity reduces both the environmental and market risks faced by agricultural producers, and so enhances well-being. But the economic value of changes to enhance agrobiodiversity and its services is rarely reflected in current market transactions, and is not taken into account by decision-makers. In many countries, users of biological resources in agroecosystems have little incentive to maintain sufficient diversity to meet the needs of agricultural production because markets for agricultural inputs and outputs do not reflect the full social opportunity costs. Economists refer to this as the problem of market failure, and to the resultant loss of biodiversity as an external effect of agricultural markets that creates excessive social costs. Ecological economics, however, offer potential solution to such policy dilemma. It calls for the evaluation of all the environmental costs and benefits associated with different modes of agriculture and thereby can succeed to identify the relative economic benefit associated with maintaining high agrobiodiversity.

Further research is needed to address the issues where ecologists and economists fail to build consensus in terms of appreciating the value of biodiversity. This can be done by identification of the key functional (ecological and socioeconomic) roles played by biodiversity, with evaluation of possible scenarios for improving the management of these key functions in agroecosystems in response to environmental or economic stress.

Resilience, for example, appears to be a useful concept which is can be valued by both ecologists and economists. Resilience refers to the capacity of a system to adapt to external changes by either returning to its original state or by evolving into a state preferable to the initial one. A basic hypothesis, shared by ecologists and economists, is that biodiversity has a number of functions which contribute to the resilience of agro ecosystems. For instance, soil biodiversity (earthworms and termites, in particular) can enhance soil fertility which enables the rehabilitation of degraded soils. Another example is that crop and tree biodiversity in agroecosystems enhances the ability of farmers to remain economically viable by diversifying their revenues under uncertain market conditions with respect to volatile market price changes of inputs, crops or tree products.

4.6 IMPACTS OF ADOPTION OF GENETIC ENGINEERED (GE) CROPS

The majority of the world's plant genetic resources is located in tropical and subtropical regions. It is primarily small farmers who preserve and take care of these resources and the related agricultural diversity. As genetically modified crops have also been cultivated in these regions for some 12 years now. An estimated 40 percent of the global acreage of transgenic, i.e. genetically modified

(GM), crops is to be found in developing and emergent countries, and, in fact, almost exclusively in just six countries: Argentina, Brazil, China, India, Paraguay and South Africa. Four crops account for 95 percent of all transgenic varieties planted: soybean, maize, cotton and canola. Genetically engineered crops are grown for industrial purposes or as animal feed.

Genetic engineering has accelerated the industrialization of agriculture and thus amplified the negative impact of farming on biodiversity. In addition, it holds new, unknown risks. The introgression of genetically modified plants into non transgenic varieties and races poses a potential threat that is currently impossible to predict. Agricultural genetic engineering is usually justified with the argument that, it can achieve a quantum leap in intensification of agriculture and accelerate breeding of varieties. So far, no evidence of this has been seen. Most of the progress in plant breeding (yield potential, drought resistance and salt tolerance) has been achieved by conventional methods.

Biodiversity is a strategic resource for the future and therefore indispensable common property. Intensification of agricultural productivity must not proceed at the expense of biodiversity, but instead must harmonize with it. In both economic and ecological terms, agricultural genetic engineering does not stand better than other innovative technologies, that promote agricultural intensification. In fact, methods such as marker assisted selection (MAS), integrated pest management and organic agriculture are more in line with the aims of sustainable intensification of agriculture.

4.6.1 Technical Aspects of Adoption of GE Crops

Till date, only two genetically induced traits have gained commercial importance: herbicide tolerance (HT) in crops and pest resistance through insertion of a gene from the bacterium *Bacillus thuringiensis* (Bt). These traits have been introduced to maximize agricultural production by countering the effects of herbicides and pests. Effects of these traits on agrobiodiversity, however, have not always been favorable. There are studies which say that these traits have been neither ecologically viable nor economically profitable in long run.

Herbicide tolerance is seen to have an effect on biodiversity. Transgenic soybean varieties have been grown in Argentina since the mid 1990s. The introduction of these varieties has enormously accelerated a trend that already existed: the large-scale expansion of monoculture cultivation of soybeans. The plants are resistant to the herbicide glyphosate, allow fully-mechanized production and require less agricultural skill than conventional varieties. Within ten years (1994 - 2004) the acreage under soybean has increased from 6 to 14 million hectares, and the share of transgenic soybean in the fields from zero to 99 percent. The Argentine government aims to increase the acreage by another four million hectares by 2010.

Bt technology is used to produce transgenic plants, cotton, for example has the Bt-toxin in its DNA. Most insects that eat the Bt toxin die, making chemical pesticides unnecessary. Experience with Bt cotton in the early years was very promising. Many studies showed that pesticide use was substantially reduced, alleviating damage to insect fauna, decreasing costs of production, and improving net incomes.

Later studies have confirmed that only Bt technology is not confined to positive results. In a study in China, researchers found that the majority of farmers had to treat their cotton fields 15-20 times more often than in the early years of growing Bt-cotton to kill secondary pests, in particular mirids (Miridae). Farmers now spend the same amount on pesticides as neighbouring non Bt growers, in addition to having to pay about 2-3 times more for Bt seed. A similar finding is reported from the leading cotton growing area in South Africa. Furthermore, the effect of Bt toxins on beneficial insects and soil microorganisms is not yet clear. To sum up therefore: based on current knowledge, the impact of Bt technology on biodiversity is at best neutral.

Genetically modified crops also leads to contamination of indigenous crops by cross-pollination. Transgenic plants, when released from the greenhouse, may cross-pollinate with other varieties and with wild relatives. This pollination is irreversible and difficult to limit regionally. Sometimes their pollen grains of such crops are found up to 21 kilometers away from where it had been cultivated. This makes the coexistence of transgenic crops with non-transgenic crops virtually impossible. The UN's Food and Agriculture Organisation (FAO) advised all international agricultural research centres to do everything possible to avoid unintentional transgenic introgression into their *ex situ* gene bank collections. However, there is evidently no consensus at present on how to deal with this challenge.

4.6.2 Monopolization and Monoculture

Within the past 25 years there has been unparalleled concentration in the seed sector that is responsible for commercial breeding and propagation. In 2006, over half of the global seed market was supplied by only ten seed corporations. As far as transgenic crops are concerned, the market is cornered by just one company (Monsanto), which provides seed directly or indirectly for approximately 90 percent of the total area under transgenic crops.

Biotechnology has not caused the monopolization of the seed sector, but it has accelerated and reinforced the process. One main reason for this is that the breeding costs for GE crops are extremely high and the necessary investment can only be borne by larger companies. Conversely, to cover these costs a standardized variety or a whole cropping technology has to be distributed as widely as possible. This development creates dependency among farmers and leads to genetic uniformity of cropping systems as reported from the United States, for instance, where farmers say that it has now become virtually impossible to find high quality, conventional varieties of corn, soy and cotton seed.

Another consequence is the increasing control of genetic resources by a few companies through patents, licenses and the like. In the past, genetic material for breeding purposes was in the public domain. Today, it has increasingly become private property, accessible only with the permission of patent holders. This gives them have a strong influence on breeding programmes and strategies and on maintenance of varieties. Today, the concentration in the seed sector is probably the greatest threat to the diversity of agricultural crops.

In terms of the national economy, this drastic change to land use and farming systems due to adoption of genetically modified crop may initially appear to be positive, but it has had a negative impact on food production and the diversity of cropping systems. For instance in Argentina, rice and potato cultivation have suffered a reduction of 40 percent and 38 percent respectively. Even higher losses have been observed with vegetables, and a similar trend has been observed with products such as milk, eggs and meat. The mixed farming systems practiced by smallholders are gradually disappearing and are being replaced by lar ge monocropped fields.

Check Your Progress 1

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) Why does agricultural intensification reduce biodiversity?

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2) How does use of GE crops promote monopolization of seed supply?

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4.7 TRADITIONAL KNOWLEDGE AND AGROBIODIVERSITY

The term traditional knowledge encompasses the knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles that are of importance for the preservation and sustainable use of biological diversity. This knowledge has been developed over the centuries and hence it is a collective asset of the local communities. It is passed on from generation to generation in such forms as stories, songs, cultural values, traditional laws, local languages, rituals, medical lore and agricultural practices.

Indigenous people and traditional local communities often have a profound understanding of their environment and its ecology. They know numerous ways of using wild plants and animals, for example as food, medicine and dyes. Different cultivation techniques have been developed for a large number of useful plants. This knowledge is an important foundation for the conservation and sustainable use of global biodiversity. In fact there are close links between cultural and biological diversity. Locally adapted cultivars, grown traditionally by the farmers have significant role in providing food security as well as environmental quality. After occurrence of natural calamities like tsunami, cyclones, revival of crop production in the affected areas depends largely on availability of these locally adapted crop varieties. Crop plant adaptation thus offers the best way to meet likely adverse impact of possible climate change.

Unfortunately, indigenous peoples suffer from the destruction of the environments in which they live. Often they are being uprooted or displaced from their native place and losing their identity. As a result of this, there is a threat that this great wealth of traditional knowledge will be lost forever. There is pressing need to protect these societies and to document the precious ecological knowledge that they have inherited across the generations.

Box 1: Local, Traditional and Indigenous Knowledge

Local knowledge is a collection of facts and relates to the entire system of concepts, beliefs and perceptions that people hold about the world around them. This includes the way people observe and measure their surroundings, how they solve problems and validate new information. It includes the processes whereby knowledge is generated, stored, applied and transmitted to others.

The concept of **traditional knowledge** implies that people living in rural areas are isolated from the rest of the world and that their knowledge systems are static and do not interact with other knowledge systems.

Indigenous knowledge systems are often associated with indigenous people. This concept is rather limiting for policies, projects and programmes seeking to work with rural farmers in general. Furthermore, in some countries, the term indigenous has a negative connotation, as it is associated with backwardness or has an ethnic and political connotation.

At the UN Conference for Environment and Development in Rio de Janeiro in 1992, there was for the first time broad recognition of traditional knowledge. Under the Convention on Biological Diversity (CBD) contracting parties have pledged to recognise and promote traditional knowledge and to make it available for general use. Access to traditional knowledge must be based on the consent of the knowledge holders and their equitable participation in the benefits arising from the use of such knowledge.

Traditional knowledge is often not confined within ethnic or geographical boundaries. In addition, biological resources and traditional knowledge are defined in the CBD as a collective asset. This contrasts with WTO usage, since the TRIPS Agreement (Trade Related Aspects of Intellectual Property Rights) defines private and individual rights to intellectual property. The contradiction between the CBD and TRIPS is as yet unresolved.

4.8 GENDER AND AGROBIODIVERSITY

In most traditional and modern farming systems there is a fixed division of labour. Men and women may be responsible for different crops or for different tasks related to a crop. Men tend to focus on market-oriented cash crop production, while women are often responsible for the family's subsistence needs. In Mali, rice was traditionally a "women's plant". Women possessed a vast store of knowledge about the native varieties they cultivated and could distinguish between

30 varieties. The men had more knowledge about cultivation of three improved varieties of rice that had been introduced into the village. In fact, how roles are assigned and who takes decisions relevant to agrobiodiversity will depend on the specific situations and culture. Depending on gender roles, the man or the woman may be the agrobiodiversity conserver.

Nutrition and health needs are most often considered the responsibility of women. It is therefore usually women who hold the knowledge of the plants and animals that serve these needs, whether with regard to their culinary, nutritional and curative properties or in connection with their agronomic and environmentally related characteristics. The variety of plants and animals contributing to subsistence is generally far larger than the range of products sold in the markets. When addressing agrobiodiversity conservation issues, therefore, it is primarily women who must be reached. There are many ways in which women in agriculture and men too can be supported in their role as conservers of agrobiodiversity. Participatory breeding, seed banks and livestock markets, tourism, home gardens, cooking, medical and religious traditions, to name but a few, are all areas with potential for successful development cooperation.

In poor families with two adults, more than half the available income comes from the labour of women and children. Furthermore, women spend most of their earnings on meeting the basic needs of their families. Women produce 80 percent of the food in Africa, 60 percent in Asia and 40 percent in Latin America. Women are the sole breadwinners in one-third of all households in the world. Male migration from rural areas to cities in search of paid employment has led to a predominantly female rural population in many areas. As men's participation in agriculture declines, the role of women in agricultural production becomes ever more dominant. Women are responsible for looking after the offspring of large livestock as well as smaller animals such as small ruminants and chicken.

Individual countries must in future formulate their agricultural policies in a way that does not exclude women. This is essential if states are to produce sufficient food for their growing populations. The fact that gender aspects have so far been neglected has had serious consequences not only for biodiversity but also for gender equality. The gender aware design of biodiversity conservation measures involves more than just taking account of traditional seed, old native varieties and traditional knowledge. If the roles of men and women are properly considered, many negative impacts on women can be avoided. Family nutrition and health are improved if a range of nutritious plants is cultivated. Improvements in production systems can increase the income of women farmers. If more attention is paid to the knowledge and skills of women, their position in society is strengthened.

Through their daily activities, experience and knowledge local farmers, and especially women, have a major stake in protecting agricultural biodiversity. However, they are still hampered by a lack of rights relating to access to and control of the resources that they rely on to meet their needs. National policies fail to take due account of the increasing responsibility of farmers for food production and the management of natural resources. Improvement of women farmers' access to land and water resources, to education, advice, training, credit and appropriate technology is essential if agrobiodiversity conservation is to be improved. Sound and equitable agricultural policies to provide incentives for the sustainable use of genetic resources are also needed.

A range of international agreements regulates the conservation and sustainable use of agrobiodiversity. Most of these agreements, however, take little account of gender issues. The United Nations Convention on Biological Diversity, however, in its preamble acknowledges the key role played by women, especially in the developing world, in the management and use of biological resources. The FAO Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture make detailed reference to the differing roles of women and men in the conservation of agrobiodiversity.

4.9 PARTICIPATORY PLANT BREEDING

Participatory plant breeding is one good approach to ensure agrobiodiversity conservation as well as agricultural sustainability. In contrast to classical approaches, breeding is not done by breeders alone, nor does it take place only in experimental fields or in laboratories. Farmers are involved throughout the entire breeding process and most of the breeding takes place in their fields. This helps to ensure better ecological adaptability of the crops towards the conditions of farmers' field. An example is the participatory barley breeding programme in Syria. Breeders and farmers make crosses and selections over several generations, according to the evolutionary breeding method. The populations thus obtained are then tested over a period of three years in field experiments. Once this stage has been completed, either the material is released as a variety or the whole process is repeated.

Participatory approach to plant breeding has many benefits. The effectiveness of breeding can be improved as the farmers' experiences, as well as their agricultural knowledge and skills, are fed into the entire breeding process. Varieties bred by this method have high acceptance and accelerated adoption rates because the farmers, as users of the new seed, are able to input their own needs and preferences. The breeding time can be reduced by several years because, in contrast to classical breeding methods, a lower DUS (distinctiveness, uniformity and stability) level is sought and variety screening trials can also be omitted. This saving of time is an important aspect during our period of rapid climate change, with the resultant need for fast adaptation of agriculture.

In socioeconomic terms, this method empowers farmers to regain control of their seed systems, and to safeguard their interests after decades of marginalization due to global trade liberalisation. From an ecological standpoint, it will become easier to exploit unfavourable sites and to tap the potential benefits of plants that have been little used in the past. The new method thus contributes substantially to improving global food production. Furthermore, it will enable us to sustain the diversity of agrogenetic resources and to develop it further for a more rapid adaptation to environmental change.

Participatory evolutionary plant breeding has emerged over the past 10 years. It is mainly supported and promoted by international agricultural research centres (e.g. ICARDA and ICRISAT) and by a number of NGOs (e.g. Misereor and Oxfam). The process is now being practised in many countries with outstanding results. Using this method to breed varieties with higher drought tolerance and better adaptation to low rainfall environments has been particularly successful. Outstanding successes include barley in the Middle East, rice in South Asia and sorghum in West Africa. The ongoing paradigm change in agriculture towards sustainable intensification must embrace the role of agrobiodiversity in general, and the need for innovation in plant breeding in particular. Evolutionary, participatory plant breeding could make a significant contribution to agriculture in the future.

4.10 INTELLECTUAL PROPERTY RIGHTS AND PLANT VARIETY PROTECTION: GLOBAL FRAMEWORK

Serious attempts for protecting intellectual property in plant varieties and seeds started in the early periods of the twentieth century. It was the legislation in U.S.A., Germany, Hungry, Italy, Netherlands, Austria, etc. in the 1930s, which really led to private monopolization of plants and business. That time private firms raised the question of plant breeder's rights in the international forum. It was followed by a counter concern for farmer's right, in particular by the developing world, under the support of the Food & Agriculture Organization of the United Nations (FAO).

In the meantime, there has been significant advancement in new technologies, particularly the biotechnology. The costs of research and investments in production have thus increased several folds. In order to safeguard the interests of investors, the Intellectual Property Rights (IPR) has emerged. Protection of IPR was necessitated either by patents or other forms of protection including the Plant Variety Protection (PVP). Whereas, the IPR protection can be granted only by the governments within their national jurisdiction, there are several international treaties, which facilitate collective action for governance of these issues.

There are a number of international level agreements related to IPR, protection of plant varieties and international trade on agrobiodiversity. Major agreements include the General Agreement on Tariff and Trade (GATT), the International Undertaking on Plant Genetic Resources (IUPGR), the Global Plan of Action (GPA), the Convention on Biological Diversity (CBD), etc. However, some international conventions were not held on the common inter governmental platform. The Convention of the Union for Protection of New Varieties of Plants (UPOV) may be listed as such Convention, which was held by the countries of the Europe.

The UPOV aimed to ensure protection of Plant Breeder's Right (PBR) by the grant of an exclusive right on the protected new plant variety on the basis of a set of uniform and clearly defined principles: distinctness, uniformity, stability and novelty, also known as DUS criteria. At present, membership of UPOV has exceeds 50 and several other countries are either its observers or these are in the process of becoming its members. Notwithstanding the fact that the UPOV system is the first system of plant variety protection, many developing countries, such as, Belarus, Croatia, Morocco, Uzbekistan, Venzuela, Zimbabwe, Philippines, India, etc. have evolved or evolving their own sui generis legislation which provide a more comprehensive framework for the plant variety protection containing several deviations from UPOV model.

Another area of concern for agriculture has been the biological diversity and genetic resources. In this context, the Convention of Biological Diversity (CBD) further recognised agricultural biological diversity as a sub set that needs specific attention for conservation, access, sustainable use including use of biotechnology, and equitable sharing of commercial benefit. The CBD considered the raw genetic resources as a management concern. The developed varieties, including those developed by the conventional approaches were, however, treated as being the finished products that required protection of intellectual property involved in their development. Also, the traditional knowledge of farmers in relation to the crop varieties or their use got specific attention under the area of protecting intellectual property rights.

The Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs) constitutes one of the important agreements of the World Trade Organisation (WTO). The TRIPs Agreement sets out clear cut options for Member countries on protection of plant varieties. This may be achieved by any one of the following, (a) patent for plant varieties, (b) an effective sui generis system of protection for plant varieties, and (c) a combination of patent and effective sui generis system for protecting plant varieties. By exercising such choice countries might allow only one or both forms of protection for varieties of all plant species or, alternately, there may be one form of protection for varieties of certain group of species and a different form of protection for other group of species.

4.11 PLANT VARIETY PROTECTION IN INDIA AND PPVFR ACT, 2001

India has ratified or agreed to various inter-governmental arrangements in larger national interest as well as in the interest of the humanity at large. India has been participating in the major United Nations led inter-governmental collaborations concerning agriculture, biodiversity and trade right from their beginning. For example, the country has been the founder member of GATT, IUPGR, GPA, CBD etc. India is its founder member and also that of its predecessor, the General Agreement on Tariff and Trade (GATT). India has observed the developments in UPOV right from the beginning although the country is not its member as yet.

Indian legislations on plant variety protection (PVP) are primarily required to be established in compliance with the international agreement, like TRIPs, which required its Members to have a sui generis legislation for IPR protection regime. Sui generis literally means 'self-generating' and sui generis system in the present context refers to a 'novel system', 'of its own kind'. Apart from meeting these requirements, such legislations have to address balance for many other national requirements and policy objectives such as those related to food security, livelihood of farming community, material exchange, trade, environment, private investment, technology transfer, etc.

In this context, the Protection of Plant Varieties and Farmer's Rights Act, 2001 of India is relevant and first of its own kind in the world. It attempts to optimise and balance claims for protection by both plant breeders and the farmers. Indian PPVFR Act, 2001, has many unique aspects. It recognizes farmer as breeder, conserver and preserver of traditional varieties of crops and wild species in addition to cultivator, either directly or indirectly. Protection is provided not only to new varieties but also to the existing varieties. Protection of varieties other than extant and farmers' varieties is limited to those genera or species notified by the Government of India in Official Gazette from time to time. A plant variety having genetic use restriction technology (GURT), like 'terminator gene', is disqualified from protection. A different and possibly less rigorous procedure is adopted for the protection of farmers' varieties. There is provision for creation of a National Gene Fund (NGF) wherein the benefit shared under the Act, shall be credited for supporting conservation at local community level including *in situ* and *ex situ* conservation of agrobiodiversity. There is provision for compulsory license for a period determined by the competent authority when a breeder or institution or their licensee fails to produce and supply enough planting material of the variety to farmers and causes its non-supply or short supply or charges prohibitively high prices for such planting material. There is also provision of Establishing Plant Variety Tribunal for speedy disposal of legal disputes related to this Act.

Indian PPVFR Act, 2001, contains an extensive list of farmers' rights including the aspects like right to register farmer's varieties; entitlement for benefit sharing for the use of biodiversity conserved by the farming community; right to save, use, sow, re-sow, exchange, share or sell farm produce including seed of registered variety but not the branded seed; right to claim compensation for under performance of a right protected variety from its promised level under defined production conditions; mandatory need to secure consent of farmer(s) when a farmer variety is used to develop an essentially derived variety (EDV); protection from legal proceedings related to alleged infringement; exclusion from paying fee in any legal proceedings in the Tribunal and Higher Courts.

There is a need to be more practical and cohesive in our approach to implement various provisions already made in the Act. This is the time to concentrate on developing a road map and establishing the institutional mechanism, including awareness generation and increasing IPR literacy and information services. The most important challenges in the pre-implementation stage of theAct are, bridging the information gaps, simplifying the interpretation of the law , and institutionalized law enforcement for the administration of justice. The need to elaborate and strengthen the area of jurisprudence related to protection of plant varieties in conformity with the TRIPs Agreement should also be realized on priority.

Check Your Progress 2

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) Why do rural women bear special significance for agrobiodiversity?

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2) How does participatory plant breeding helps in agrobiodiversity conservation?

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4.12 LET US SUM UP

- The growing pressure on agricultural landscapes is leading to agricultural intensification which results into loss of agrobiodiversity and its services.
- Modernization of agriculture is due to many factors including rapid population growth, breakdown of traditional institutions, and stronger market forces, exacerbated by the role of agribusiness and international trade pressures.
- Genetic engineering has accelerated the industrialization of agriculture and thus amplified the negative impact of farming on biodiversity.
- Methods such as marker assisted selection (MAS), integrated pest management and organic agriculture are more in line with the aims of sustainable intensification of agriculture as compared to genetically engineered crops.
- Traditional knowledge is an important foundation for the conservation and sustainable use of global biodiversity. In most traditional and modern farming systems there is a fixed division of labour between the two genders.
- Participatory plant breeding is one good approach to promote agrobiodiversity in which farmers are involved throughout the breeding process and most of the breeding takes place in their fields.
- With the advancement in technologies, particularly the biotechnology, the costs of research and investments in production have increased several folds. In order to safeguard the interests of investors, the Intellectual Property Rights (IPR) have emerged at national and international levels.
- The Protection of Plant Varieties and Farmer's Rights Act, 2001 of India is relevant and first of its own kind in the world. It attempts to optimize and balance claims for protection by both plant breeders and the farmers.

4.13 KEY WORDS

Genetically Engineered (GE) Crop : Crop produced by alteration of genetic material through introduction of genes of other organism by use of biotechnology.

Intensive agriculture : Agriculture which is based on the principle of high input and high output. Fertilizers, irrigation and pesticides are some of the inputs.

Marker Assisted Selection (MAS) : It is a method in which gene-markers are used to identify desired traits more easily and can be used as early as the seedling stage of a plant and it also allows wild relatives to be included more easily.

Integrated Pest Management : Control of pests by use of physical, chemical and biological means

Organic agriculture : Agriculture based on use of biological resources as inputs like farm yard manure, green manure etc.

Intellectual Property Rights: Legal framework to compensate or protect the interest of person or community who innovated a particular product or idea, often with some commercial prospects.

4.14 REFERENCES AND SUGGESTED FURTHER READINGS

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- http://www.agrobiodiversity-diversitas.org/
- http://agrobiodiversityplatform.org/
- http://www.fao.org/biodiversity/en/

4.15 KEY TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Your answer must include the following points:
   - Use of lesser number of crop species
   - Species loss due to clearing of forests for agriculture
2) Your answer must include the following points:
   - Process of making GE crops is very expensive and only big firms can afford it
   - Processes like patenting and licensing also restrict their production

Check Your Progress 2

1) Your answer must include the following points:
   - They have good knowledge about traditional crops and their conservation
   - They particularly know about the several crops important for subsistence
2) Your answer must include the following points:
   - It involves farmers in breeding and hence their traditional knowledge is incorporated which is good for agrobiodiversity conservation
   - Crop breeding is done in the farmers field and hence the resultant crop seeds have better adaptability to the local environmental conditions