AGROBIODIVERSITY CONSERVATION AND SUSTAINABLE USE IN ENHANCING FOOD SECURITY

(A Training Manual)

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PREFACE

This training manual will support integration of agrobiodiversity curricula in Kenyan training institutions. The manual is based on knowledge generated from case studies, and it provides an understanding of sustainable use, agrobiodiversity (AGBD) and soil quality, economics of agrobiodiversity, uptake pathways of agrobiodiversity technologies and ecosystem management with relevance to local knowledge ownership, gender and household food security. It is intended to build capacity of personnel in agriculture and rural development sectors and create competency in addressing agrobiodiversity issues.

The manual builds on earlier publications and has incorporated new topics which expand the understanding of agrobiodiversity as a system and not as a topic. This expanded approach makes it easier for the subject to be included in the curricula of institutions of higher education. The manual shows the place of agrobiodiversity in different disciplines.

This manual is intended for use as a conceptual guide by trainers and as resource material for agrobiodiversity workshops targeting middle level college graduates and extension practitioners. It is also appropriate for general readership for researchers, academicians, policy makers and other professionals engaged in agrobiodiversity related community work.

The manual comprises of ten modules with topics selected carefully to include key issues of agrobiodiversity in our local situation. The topics include role of agrobiodiversity in food security, agrobiodiversity, local knowledge and ownership, agrobiodiversity and gender, agrobiodiversity and ecosystem management, sustainable use and conservation, agrobiodiversity and soil quality, economics in agrobiodiversity, uptake pathways of agrobiodiversity technologies and agrobiodiversity and climate change. Selected case studies and exercises have been included to enhance understanding of the modules. At the end of each module, a list of key points is provided to give the reader a quick overview of the module content.

Module 1:	Introduces concepts of conservation of agrobiodiversity for enhanced food security
Module 2:	Discusses the relationship between agriculture, biodiversity, food security and nutrition
Module 3:	Explains the current location of genetic diversity, nature of germplasm flow and legal rights and degree of interdependence among nations
Module 4:	Introduces the concept of gender within agrobiodiversity management
Module 5:	Analyses the role of biodiversity in an ecosystem and the role of agrobiodiversity in ecosystem management
Module 6:	Focuses on options for sustainable use and conservation of agrobiodiversity including principles and approaches.
Module 7:	Discusses functional diversity and soil quality; nutrient cycling and role of cropping systems in agrobiodiversity
Module 8:	Provides the economic techniques used to design a profitable co-existence of diverse farm enterprises
Module 9:	Identifies appropriate pathways for enhancing uptake and use of agrobiodiversity.
Module 10:	Discusses effects of climate change on AGBD and mitigation strategies against such effects.

Training Approach

Any training programme using this manual will consider the interests and expectations of participants. It will draw on participants' own experiences and knowledge. The modules are task oriented, involving group work and guided case study assignments. The programme can introduce new developments and AGBD related concepts. Excursions and field study should be undertaken to illustrate the state of AGBD in the region. The course will approach AGBD use and conservation from an integrated, participatory and interdisciplinary perspective, which will assist participants to integrate and apply what they will have learnt.

ACKNOWLEDGEMENTS

This work was accomplished through the efforts of many players drawn from Egerton University and FAO. We wish to appreciate the contribution of the FAO-Netherlands Partnership Programme (FNPP) for the financial support of an Agrobiodiversity Training Workshop held at Egerton University in May, 2008 and a workshop in July, 2008 (for improving the training material). We also wish to thank Dr. Michael Makokha (Coordinator, FNPP) for the role he has played in facilitating the preparation of this manual and other agrobiodiversity activities at Egerton University. Our special thanks go to the participants of the first training workshop for sharing their experiences and providing useful suggestions on the content and presentation of the modules. Lastly we wish to express our appreciation to Egerton University, through the Dean, Faculty of Agriculture and Division of Research and Extension, for their immense support in the preparation of this work.

CONTENTS

PREFACE .... **ii**
Training Approach iii
ACKNOWLEDGEMENTS .... **iii**
ACRONYMS .... **vi**
DEFINITIONS .... **vii**
Module 1: Introduction to Agrobiodiversity **1**
10. Learning Objectives 1
1.1. Overview of Agrobiodiversity 1
1.2. Importance of Agrobiodiversity 1
1.3. Status of Agrobiodiversity 3
1.4. Ownership of Agrobiodiversity 4
1.5. Key Points 5
Module 2: Agrobiodiversity in Food Security and Nutrition **7**
2.0 Learning Objectives 7
2.1. Agrobiodiversity on the World Food Situation 7
2.2. Food Security 9
2.3 Livelihoods 12
2.4 Agrobiodiversity in Nutrition 12
2.5. Key Points 16
Module 3: Ownership of Agrobiodiversity and Local Knowledge **17**
3.0 Learning Objectives 17
3.1 Agrobiodiversity and Ownership 17
3.2 Legal Frameworks in the Management of Agrobiodiversity 18
3.3 The Kenyan situation on patents 22
3.4 Geographical Distribution of Genetic resources 25
3.5 Local Knowledge and Agrobiodiversity 27
3.6 Key points 29
Module 4: Agrobiodiversity and Gender **31**
4.0 Learning Objectives 31
4.1 Definition of Gender 31
4.2 Gender Roles and Gender Relations 31
4.3 Gender Mainstreaming 33
4.4 Gender in Agrobiodiversity Conservation 34
4.5 Gender and Agrobiodiversity Management 35
4.6 Key Points 35
Module 5: Agrobiodiversity and Ecosystem Management **37**
5.0 Learning Objectives 37
5.1 What is an Ecosystem? 37
5.2. Agro ecosystems and Agrobiodiversity 38
5.3 Agrobiodiversity and Ecosystem Function 39
5.4 Agricultural production and agrobiodiversity 41
5.5. Agro ecosystems Management 42
5.6: Key points 46

Module 6: Sustainable Use and Conservation of Agrobiodiversity....48
6.0 Learning Objectives 48
6.1 Why Conserve Agrobiodiversity?....48
6.2 Erosion and Loss of Agrobiodiversity....49
6.3 Approaches to Conservation of Agrobiodiversity 52
6.4 Incentives for Community-Based Conservation through Utilization 54
6.5.Practical Steps for Implementation of a Community-Based Conservation Programme 57
6.6. Developing the Genetic Resources of Communities....58
6.7. Differences between AnGRs and PGRs, and their Management 59
6.8. Key Points....61
Module 7: Agrobiodiversity and Soil Quality 63
7.0 Learning Objectives 63
7.1 Agrobiodiversity Effects on Soil Quality 63
7.2 Soil Biological Diversity and Nutrient Cycling....65
7.3 Cropping Systems and their Benefits to Agrobiodiversity 68
7.4. Soil Quality Assessment 70
7.5 Key Points....73
Module 8: Economics in Agrobiodiversity 75
8.0 Learning Objectives 75
8.1 Role of Economics in Agrobiodiversity....75
8.2 Economic Decisions Farmers face in Agrobiodiversity....78
8.3 Challenges in Choice of Input and Farm Enterprise in Agrobiodiversity 78
8.4 Farmer Risk and Uncertainty in Agrobiodiversity 82
8.5 Basic Records....83
8.6 Application of Economic Principles....85
8.7 Key Points....85
Module 9: Uptake Pathways for Agrobiodiversity (AGBD) Technologies....87
9.0 Learning Objectives 87
9.1 Why Promote Agrobiodiversity Technologies 87
9.2 Uptake Pathways for AGBD Enhancing Technologies 88
9.3 Barriers to Uptake of AGBD Enhancing Technologies....92
9.4 Key Points....95
Module 10: Climate Change and Agrobiodiversity....96
10.0 Learning Objectives 96
10.1. Introduction and overview 96
10.2. Indicators of climate change 96
10.3. Effects of Climate Change on AGBD 98
10.4. Mitigation strategies against effects of climate change 98
10.5. Key Points 99

ACRONYMS

AGBD	Agrobiodiversity
AnGR	Animal Genetic Resources
BSE	Bovine Spongiform Encephalopathy
CBD	Convention on Biological Diversity
CGRFA	Commission on Genetic Resources for Foods Agriculture
COP	Conference of the Parties
CSO	Civil Society Organisation
EU	European Union
FAO	Food and Agriculture Organisation
FEWS	Famine Early Warning Systems
ICPOV	International Convention for Protection of New Varieties of Plants
IPAR	Integrated and Participatory Agriculture
IPR	Intellectual Property Rights
IT-PGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
LSQI	Local Soil Quality Indicator
NDVI	Normalized Difference Vegetation Index
NGO	Non Governmental Organisation
OAU	Organisation of African Unions
IOE	International Office of Epizootics
PBR	Plant Genetic Resources
RFE	Rainfall Efficiency
SQI	Soil Quality Indicators
TRIPS	Trade Related Intellectual Property Rights
UN	United Nations
UPOV	International Union for the Protection of New Varieties of Plants
WRSI	Water Reserves Substitution Index
WTO	World Trade Organisation

DEFINITIONS

Adaptation (climate change) - refers to changes in processes, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate.

Agrobiodiversity (AGBD): AGBD is the variety and variability of animals, plants and microorganisms 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 microorganisms, 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 (FAO 1999).

Animal/ plant genetic resources (AnGRs/PGRs): AnGRs/ PGRs are defined as those animal/ plant species that are used, or may be used, for food production and agriculture, and the populations within each. Distinct populations within species are usually referred to as breeds or varieties.

Breed/ variety at risk: A breed/ variety that has been classified as critical, critical-maintained, endangered, or endangered-maintained is said to be a breed/variety at risk.

Breed/ variety: A breed or a variety is a sub-specific group of domestic livestock or plant with definable and identifiable external characteristics that enable it to be separated by visual appraisal from other similarly defined groups within the same species or a group for which geographical and/or cultural separation from phenotypically similar groups has led to acceptance of its separate identity.

Climate change United Nations Framework Convention on Climate Change (UNFCCC) definition will be adopted and states that climate change is the change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Climate system is the totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions.

Climate variability - denotes deviations of climate statistics over a given period of time (such as a specific month, season or year) from the long-term climate statistics relating to the corresponding calendar period.

Critical: For livestock, a breed is categorized as critical if the total number of breeding females is less than or equal to100 or the total number of breeding males is less than or equal to five; or the overall population size is less than or equal to 120 and decreasing and the percentage of females being bred to males of the same breed is below 80 percent, and it is not classified as extinct.

Critical-maintained: Critical-maintained populations are those populations for which active conservation programs are in place or populations are maintained by commercial companies or research institutions.

Endangered: For livestock, a breed is categorized as endangered if the total number of breeding females is greater than 100 and less than or equal to 1000 or the total number of breeding males is less than or equal to 20 and greater than five; or the overall population size is greater than 80 and less than 100 and increasing and the percentage of females being bred to males of the same breed is above 80 percent; or the overall population size is greater than 1000 and less than or equal to 1200 and decreasing and the percentage of females being bred to males of the same breed is below 80 percent, and it is not assigned to any of the above categories.

Endangered-maintained: Are those populations for which active conservation programs are in place or populations are maintained by commercial companies or research institutions.

Extinct breed: A breed/ variety of plant is categorized as extinct when there are no breeding males or breeding females (for animals) or genetic material (for both animals and plants) remaining. Nevertheless, genetic material might have been conserved to allow recreation of the breed/ variety. In reality, extinction may be realized well before the loss of the last animal/ plant or genetic material.

Food security: This is the constant availability of quality and abundant food at all times for the human race. It exists when all the 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 lifestyle.

Greenhouse effect:- The result of water vapour, carbon dioxide, and other atmospheric gases trapping radiant (infrared) energy, thereby keeping the earth's surface warmer than it would otherwise be. Greenhouse gases within the lower levels of the atmosphere trap this radiation, which would otherwise escape into space, and subsequent re-radiation of some of this energy back to the Earth maintains higher surface temperatures than would occur if the gases were absent.

Greenhouse gases - are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation.

Indigenous knowledge/ local knowledge: Indigenous knowledge is the information people in a given community have developed over time. It is usually based on experience, adapted to local cultures, and environment and is developed continuously. The knowledge is used to sustain the community, the culture and helps to maintain the genetic resource necessary for the continued survival of the community. Many indigenous livestock keepers have large vocabularies to describe the various types and colours of animals, and to classify their products. The number of terms used is a useful indicator of the indigenous knowledge about the breed.

Intellectual property rights: These are policies put in place by ownership and exchange of plant and animal genetic resources for food and agriculture to bind or protect rights of farmers or breeds and their technologies. It is designed to ensure that all technologies and their products may be patented, including those that were formally considered unsuitable for patenting. Several elements covered by the agreement potentially affect the management of AnGRs/ PGRs.

International treaty: An agreement at national or international fora that deals with complexity and contentious bio-political issues on who owns what. These include FAO, CBD, WTO, etc.

Terminologies

The frameworks include both legally binding and nonbinding instruments. The term "soft law" is used to refer to non-binding legal instruments, which are utilized for a variety of reasons, including strengthening member commitment to agreements at the policy level and reaffirming international norms, and establishing informal precedents for subsequent treaties.

Vulnerability - is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes**.**

Module 1: Introduction to Agrobiodiversity

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10. Learning Objectives

At the end of the module, the trainee is expected to have an understanding of the following:-

i. Importance of agrobiodiversity,

ii. General overview of the status of agrobiodiversity, and

iii. General aspects of ownership of agrobiodiversity.

1.1. Overview of Agrobiodiversity

Agrobiodiversity encompasses the variety and variability of animals, plants and micro-organisms that are necessary for sustaining key functions of an agro-ecosystem, including its structure and processes for and in support of food production and security. Local knowledge and culture are considered integral parts of agrobiodiversity since it is the human activity of agriculture that shapes and conserves the biodiversity.

Agrobiodiversity is the result of a natural selection process and the careful and inventive developments of farmers, herders and fishers over millennia. Agrobiodiversity is a vital subset of biodiversity and forms an important means or source of food and livelihood security for many people when the resources are well sustained and managed. Agrobiodiversity or the genetic resources for food and agriculture include the following:-

- Harvested crop varieties, livestock breeds, fish species and non-domesticated resources within fields, forests, and rangelands, including tree products, wild animals hunted for food and in aquatic ecosystems;
- Non-harvested species in production eco-systems that support food provision, including soil micro-biota, pollinators and other insects such as bees, earthworms and butterflies;
- Non-harvested species in the wider environment that support food production ecosystems (agricultural, pastoral, forest and aquatic systems).

1.2. Importance of Agrobiodiversity

Agrobiodiversity encompasses social-cultural, economic and environmental elements. About one third of the world's land area is used for food production; implying agriculture is an important determinant of biodiversity. Biodiversity provides not only food and income but also raw materials for clothing, shelter, and medicine. It includes breeding new varieties and performs other services such as maintenance of soil fertility and conservation, all of which are essential for human survival. All domesticated crops and animals result from human management of biological diversity, which is constantly responding to new challenges to maintain and increase productivity.

Valuable ecological processes that result from interactions among species and between species and the environment include, *inter alia*, biochemical recycling, the maintenance of soil fertility, water quality and climate regulation such as micro-climates caused by different types and densities of vegetation.

Contribution of agrobiodiversity to national economies

According to Thrupp (1997), the following benefits can be derived from agrobiodiversity:-

- Increased productivity, food security and economic returns;
- Reduced pressure of agriculture on fragile areas, forests and endangered species;
- More stable, robust and sustainable farming systems;
- Sound pest and disease management;
- Soil conservation, increased natural fertility and health;
- Sustainable intensification of agriculture;
- Diversity in products and income opportunities;
- Reduced or spread risks;
- Maximized effective use of resources and the environment;
- Reduced dependency on external inputs;
- Improved human nutrition, and provision of medicine and vitamins;
- Conserved the ecosystem structure and stability of species diversity.

In all regions, livestock and plants contribute significantly to food production and economic output. The relative importance of agriculture in total GDP is greatest in developing regions, with the highest proportion being in Africa. In many parts of the world, livestock and crop production are important elements in the livelihoods of large numbers of people, and contributes more than the marketable products that are considered in economic statistics. Figures are available at community, district or country levels, but on a larger scale, gaps in the data means that accurate estimations are difficult to make (Thornton *et al.,* 2002).

Other useable livestock by-products include horns, hooves and bones, used on small-scale for the production of various decorative items, tools and household goods, and in the production of glue and gelatine. Meat and bone meal was an important source of feed protein in livestock production before the rise of Bovine Spongiform Encephalopathy (BSE).

Draught power provided by animals contributes greatly to crop production in the developing world. Animal traction has traditionally been particularly important in Asia and relatively unimportant in sub-Saharan Africa where its use has been restricted by heavy soils and the presence of tsetse flies. Nonetheless, animal traction is of great importance in many parts of Africa. In the Gambia, for example, 73.4 percent of crop fields are cultivated using animal power (CR Gambia, 2003).

In Latin America, the Caribbean, and in the near and Middle East, animal power is again vital to the livelihoods of many small-scale farmers. In many parts of the world, the use of animal traction is declining as a result of increased mechanization. Some factors continue to favour livestock as a source of power. Where farmers find fuel prices unaffordable, the use of draught animals remains popular and may even increase. Animal power is used for many agricultural purposes such as, weeding, ploughing, threshing, and levelling fields before and after sowing. Many households that own draught animals hire them out frequently as a source of income.

1.3. Status of Agrobiodiversity

There are different ways of using plants as food and for other purposes. Unfortunately, these are often overlooked, posing a threat to the food reserves. The result is erosion due to neglect by the scientific community, insufficient knowledge and inadequate support for institutions and communities that conserve the biodiversity. Traditional crops are being displaced in many areas, to the detriment of the local communities, partly because they have been neglected by scientists in favour of recently introduced species and improved breeds/ varieties.

Food production systems used by the local farmers are under threat. They include local knowledge, culture and skills learnt over the years. With this decline, agrobiodiversity is disappearing and the scale of the loss is extensive. With the disappearance of harvested species, varieties or breeds, a wide range of un-harvested species also disappear.

The following are some important trends in agro biodiversity over the last 100 years (FAO, 1999b):-

- 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.
- Thirty percent of livestock breeds are at risk of extinction, with six breeds being 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. Only three (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 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. 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 increase the genetic erosion of agrobiodiversity.

Fallow fields and wild lands can support large numbers of species useful to farmers. Besides supplying calories and proteins, wild foods supply vitamins and other essential micro-nutrients. Generally, poor households rely on access to wild foods more than the wealthier. However, in some areas, pressure on the land is so great that the wild food supplies have been exhausted.

Agrobiodiversity has declined throughout the 20^{th} century mainly due to the following principles:-

- Rapid expansion of industrial and green revolution agriculture;
- Globalization of the food system and marketing;
- Genetic erosion of crops due to the replacement of local varieties by improved or exotic variety species.

1.4. Ownership of Agrobiodiversity

Farmers need formal recognition for the preservation, development and improvement of animal and plant genetic resources. This recognition forms the basis for demand for the international community to provide future support for these activities.

Conventional Biological Diversity has laws that bind or protect the right of farmers to dispose of their own biological diversity. These laws include (AnGR and PGRs. They are useful in that each country is responsible for administration of rights to genetic and biological resources, and is seen as a legal right of ownership. In addition to regulation of access to the resources, appropriate share of potential profits from the use of these resources should also be assured. The United Nations and players have put in place international-level legally binding instruments and 'soft laws' by which national governments undertake to address the management and conservation of biodiversity and develop policies on how, to implement them.

Indigenous communities have developed livestock breeds and plant varieties, and the knowledge associated with their management. Scientific institutions and commercial enterprises may further develop such materials in the same country or elsewhere. In such circumstances, controversies may arise over access to genetic material and the distribution of accruing benefits. A number of international frameworks attempt to address the issue. The CBD recognizes the importance of ensuring "the fair and equitable sharing of the benefits arising from the utilization of genetic resources". Due to this; IPRs are granted in order to provide innovators with a greater opportunity to capture the benefits arising from the products of their inventiveness.

The rights of farmers are invested in the international community and help to ensure that the need for conservation is globally recognized and that sufficient funds for these purposes are availed; assist farmers and the farming communities in all regions of the world, especially in the areas of origin/ diversity of AnGRs and PGRs, in the protection and conservation of their AnGRs and PGRs and the natural biosphere; to allow farmers and their communities in all regions, to participate fully in the benefits derived currently and in the future, from the improved use of AnGRs and PGRs through plant breeding and other scientific methods. Farmer's rights include protection of traditional knowledge, relevant to AnGRs and PGRs for food and agriculture, the right to participate equitably in sharing benefits, arising from the utilization of AnGRs and PGRs for food and agriculture and the right to participate in decision making at the national level, on matters related to the conservation and sustainable use of AnGRs and PGRs.

Institutional frameworks that have a clear mandate and that function well are vital in the implementation of laws and policies. Two main approaches to institutional development include the establishment of *ad hoc* bodies to meet particular needs and the optimal use of existing institutions with possible adjustment of their mandates or structures (FAO, 2005). Because the management of AnGRs is a complex task which involves a variety of stakeholders, implementation of legal measures may be difficult and costly. As noted above, it may be more cost-effective to use other mechanisms to achieve the desired objectives. Measures might include subsidies of various kinds, depending on the economic means of the country. In 2007, the International TechnicalConference on AnGRs. Representatives of organizations of pastoralists, indigenous peoples and smallholder farmers from both North and South discussed issues related to Livestock Genetic Diversity and Livestock Keepers' Rights. This shows the significance attached to animal genetic biodiversity the world over (http://www.fao.org/newsroom/en/news/2007/1000650/index.html).

1.5. Key Points

- Agrobiodiversity is a vital subset of diversity which is developed and actively managed by farmers, herders and fishers
- Many components of agrobiodiversity would not survive without human Intervention.
- Local knowledge and culture are integral parts of Agrobiodiversity management.
- Many important agricultural systems are based on 'alien' crops or livestock species.
- Crop diversity within species is as important as diversity within species.
- The loss of forest cover, coastal wetlands, 'wild' uncultivated areas and the destruction of the aquatic environment exacerbate the genetic erosion of Agrobiodiversity.
- Local diverse food production systems are under threat and within them, the accompanying local knowledge, culture and skills of food producers.
- The main cause of genetic erosion in animals and plants, as reported in most places, is the replacement of local breeds and varieties by improved or exotic varieties and Species.
- There are legal policies put in place to bind or protect the rights of farmers or breeds/ varieties as well as their technologies. The policies or agreements are at national or international levels and deal with complex and contentious bio-political Environment of ownership rights.

Exercise

Objective: To recognize the contribution of agrobiodiversity in Kenya.

Time: 20 minutes

Method: Small group discussion for 15 minutes and 5 minutes presentation.

Materials: Flip charts and felt pens.

Questions:

1. Discuss and summarize ways to conserve and utilize agrobiodiversity in Kenya.
2. Discuss and summarize the contribution of agrobiodiversity in Kenya's Vision 2030.

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Module 2: Agrobiodiversity in Food Security and Nutrition

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2.0 Learning Objectives

By the end of the module the participants will have understood and appreciated the issues on:

i. Effects of agrobiodiversity on the world food situation
ii. The role of agrobiodiversity in modern agriculture
iii. How agrobiodiversity can influence food security
iv. The effect of agrobiodiversity in nutrition

2.1. Agrobiodiversity on the World Food Situation

Approximately 850 million people suffer malnutrition and over 200 million children under the age of five have energy and protein deficiency. Yet any human population is entitled to an environment that is food secure. Despite the remarkable advances made by agricultural research in past years, poverty, food insecurity, and malnutrition still remain as the most critical challenges facing the developing world. The developing world:

i. Is the home to 38% of the developing countries' poor, 75% of whom are in the rural areas.
ii. Over 45% of the world's hungry and more than 70% of the world's malnourished children live in the third world.

The solution to all these is agriculture that is largely based on traditional knowledge systems called agrobiodiversity:-

i. Agrobiodiversity comprises the whole plant resource diversity that human societies use and manage for agriculture, food, healthcare, and livelihood.
ii. It includes the enormous diversity of crops and crop varieties that small-scale farmers conserve and cultivate, representing both the basis for their subsistence and a source of income.
iii. To some extent, it also embraces wild food and medicinal plants that rural populations use for nutrition, healthcare and livelihood purposes.
iv. The maintenance and use of agrobiodiversity relies on extensive indigenous knowledge systems, which address aspects such as cultivation practices, uses, and genetic resource management of such plant species.
v. The fundamental roles of agrobiodiversity and the associated knowledge in sustaining the agricultural dynamics of rural communities throughout Sub-Saharan Africa have been absent from policies and programmes related to agriculture, natural resource conservation, and rural development.

However, agrobiodiversity represents locally available resources with enormous value and potential for food security and rural development.

All too often, the only assets which remain in poor rural communities for livelihood and even survival are the local biodiversity; these assume increasing significance as other resources dwindle or disappear.

Among millions of poor and small-scale farmers, agrobiodiversity represents the foundation of

- food security,
- livelihood options and
- well-being.

The interaction between agrobiodiversity and indigenous knowledge provides the rural poor with numerous benefits and opportunities, such as capacity to address environmental conditions, provision of food and nutritional supplies, access to local market opportunities, and options to cope with evolving needs.

Traditional/Modern Agriculture

Modern agricultural models have promoted high material inputs at the farmer level, such as the regular purchase of chemical products and improved seeds. That has however impaired the economic development of small-scale farmers, as the investment efforts have not often resulted in increased gains, but in a downward cycle of financial debits, development dependency, environmental degradation, and health decline. Further, modern agricultural and development forces have persistently neglected and eroded agrobiodiversity. They have accelerated, albeit inadvertently, their depletion and depreciation at the grassroots level. The narrow focus on market-oriented agricultural components and cash crop farming has impaired the conservation, valuation and use of agrobiodiversity, eliminating many options for food security and nutrition among the rural poor.

Agricultural Diversification

Agricultural diversification is the agricultural practice that seeks the dynamic integration of the broad natural resource diversity from the genetic to the ecosystem level. It represents a key strategy to combat food insecurity. It is also the basis for providing and enhancing a balanced nutritional food supply among poor rural families, particularly in the context of subsistence agriculture and socio-economic marginalization. Agricultural diversification also provides a local mechanism to manage agro-ecological risks. The promotion of agricultural diversification encourages the production of many crops and farming approaches, as opposed to modern agricultural development paradigms, and enhances the local control over food production and nutrition.

In addition, agricultural diversification can help to alleviate labour shortages, as it allows for division of labour. Agrobiodiversity and indigenous knowledge are critically relevant for agricultural diversification efforts; in fact they have traditionally supported diversified agricultural systems. Besides the agro ecological benefits, agricultural diversification is especially relevant for poor and small-scale farmers who are faced with food insecurity, socio-economic marginalization and labour shortages.

Low-input Agriculture

Low-input agriculture aims at increasing the net economic gains of farming households, and stops the related ecological and health impact. This represents a relevant strategy for poor farmers, more so in the context of AIDS. Overall, the success of low-input agriculture is highly dependent on local crop genetic resources (as they have coevolved with local agro-ecological conditions, on the optimal use of

Indigenous knowledge which contains advanced understanding of the farming constraints and potential in a particular agro-ecological area), and on enhancing the seed autonomy of farmers (so as to ensure seed availability and access). Consequently, the focus on agrobiodiversity and indigenous knowledge may support more economically viable agricultural systems.

Home Gardens

Home gardens are an important agricultural enterprise in many rural communities throughout Africa, yet they are largely neglected. In general, home gardens and their associated crop diversity represent an excellent foundation to enhance household food security and nutrition. Home gardens and bushes are very important source of agrobiodiversity. These tend to increase dietary diversity. Food sources such as fruits, minor vegetables and leaves are used as condiments. Improving home gardening requires the optimal use of local agrobiodiversity, as well as a dynamic integration of additional crops and crop varieties with specific values and uses. Many neglected crops, such as the enormous diversity of African leafy vegetables, constitute important plant genetic resources for promoting and improving home gardening, and hence for enhancing household food security and nutrition. In addition, home gardening may expand household income-generating opportunities in view of increasing food demand from urban populations. In some cases, highly valuable wild food plants may be considered for cultivation, in the home gardens. In fact, the domestication of many crops evolved from an increased value and use among people.

Wild Foods (Plants and Animals)

As rural communities confront hunger and malnutrition, the increased use of wild foods represents a strategy for food security and nutrition. The value and potential of wild food in the nutrition of rural people is however neglected in agricultural and environmental programmes. The promotion of wild food requires the simultaneous support for community ecological conservation and management systems, to facilitate equitable access and ensure sustainable use. Hunting is a very valuable source of wild foods among the rural poor.

2.2. Food Security

“Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy lifestyle ” (WFS, 2002).

Several factors are necessary to ensure food security:

i. Alleviation of poverty and improved access to food;
ii. Ensuring agricultural trade security;
iii. Promoting rural development;
iv. Assisting developing countries to meet international food standards;
v. Enhancing access to food by all;
vi. Preparing for disasters and emergencies and Undertaking agricultural research and development.

Food security at all levels of life can be affected by climate, war, floods, drought, population growth, lack of effective agricultural practices and restrictions to trade. Food security essentially is linked to the economic and social health of a nation, society and individual.

Box 2.1. A Case Study on Food Security in Africa

Drawing on case studies from the sub-Saharan countries, the focus should be on policy, programming and institutional issues related to addressing food security in protracted crises and fragile states, with a focus on areas afflicted by conflict. The case studies illustrate how dysfunctional institutions are at the root of structural food insecurity and show how local people and institutions have been able, to a certain extent, to adapt and cope with the crises. However, the protracted nature of the crises has substantially eroded people' assets and weakened the capacities of traditional safety net systems to provide protection. Against this background, mainstream humanitarian assistance- which has been the international community's dominant response has not been able to address the basic determinants of food security and in particular has not sufficiently supported the positive efforts of local institutions. The case studies illustrate some innovative approaches for addressing food insecurity during protracted crises. They show that while it remains indispensable to ensure neutrality for immediate responses that protect the most vulnerable, it is also crucial to take into account institutional and policy dynamics that support processes to rebuild resilience; create opportunities for strengthening the livelihoods of affected population at the very early stages of the crisis; and develop and adequate basket of interventions to address a variety of needs (OECD, 2004).

The most important aspects of food security are food safety and quality, environmental concerns, gender equity and children and nutrition.

Food safety and quality entails the following:

- Establishing and improving national regulatory frameworks for food control and quality assurance compatible with international requirements, in particular those of the *Codex Alimentarius* (Latin for 'food code' or 'food book' is a collection of internationally recognized standards, codes of practice, guidelines and other recommendations relating to foods, food production and food safety.
- Supplying technical advice and expertise for the development of integrated food control systems, thus building capacity in food safety and quality throughout the food chain;
- Providing independent scientific advice, risk assessments and related guidance concerning food safety to the *Codex Alimentarius* Commission and governments, including the assessment of food additives, chemical and microbiological contaminants, naturally occurring toxicants, and foods derived from modern biotechnology;
- Developing guidelines and tools on food safety risk assessment and its use in food safety risk management, and on capacity building in various aspects of food safety and quality;
- Assisting in emergency or crisis situations through the provision of food safety guidance.

Challenges to Food Security

Global food security will remain a worldwide concern for the next 50 years and beyond. Recently, crop yield has fallen in many areas because of declining investments in research and infrastructure, as well as increasing water scarcity. Climate change and HIV/AIDS are also crucial factors affecting food security in many regions. Although agro ecological approaches offer some promise for improving yields, food security in developing countries could be substantially improved by increased investment and policy reforms (Rosengrant and Cline,2005). Further, the world over the feeling is that the international community should increase the resilience of world's food systems to climate change. It is essential to address the question of how to increase the resilience of present food production systems to challenges posed by climate change. Governments are urged to assign appropriate priority to the agriculture, forestry and fisheries sectors, in order to create opportunities to enable the world's smallholder farmers and fishers, including indigenous people, in particular vulnerable areas, to participate in, and benefit from financial mechanisms and investment flows to support climate change adaptation, mitigation and technology development, transfer and dissemination. We support the establishment of agricultural systems and sustainable management practices that positively contribute to the mitigation of climate change and ecological balance.

Box 2.2. Challenges of Food Security

Climate change: Implications for agriculture in the Near East, shows that the food security of those who are poor, malnourished or dependent on local food production could be adversely affected by climate change. Climate change will affect food security in all its four dimensions - food availability, food accessibility, food stability and food utilization. Food security is particularly threatened in the already vulnerable regions - sub-Saharan Africa, South Asia and parts of the Middle East," he said. Shifts in rainfall patterns could affect crops, particularly rice, in many countries in the region, said the FAO report, which has singled out Yemen as being particularly at risk because of its endemic poverty, rapidly growing population and acute water shortages. High food prices are on everyone's lips across the Middle East. On 3 March, 2008 Prime Minister of Bahrain Sheikh Khalifa Bin Salman al-Khalifa used his weekly meeting with officials and ordinary people to address the issue of food security in the region: "We need to draw lessons from the current spiralling inflation hitting the world and start seriously to think about ensuring food security in the Arab world," he said (FAO, 2008)

Yet another challenge for food security is alternative use of grains for fuels. For instance, the United States hopes to become energy independent with the help of bio fuels. But some believe those U.S. dreams will have a negative impact on the rest of the world. *A tremendous amount of land that is devoted to agriculture for feeding people is going to be devoted to agriculture to fuel cars in the north. So the impact on food security is going to be huge (*Miguel Altieri at the University of California at Berkeley). Further, some plants grown to be used for production of bio fuels (e.g. *Jatropha* spp.) are invasive and have negative environmental effects.

2.3 Livelihoods:

Livelihoods are the sum of ways in which people make a living. In most communities within the low-income countries, poor families balance a set of food and income-earning activities.

Types of livelihoods include livestock keeping; agriculture (crop production); agro-pastoralism; fishing; labour-based and hunter-gatherer. We study livelihoods because it is the one piece of information that can reveal how, and why, people survive (or fail to survive) difficult times (Box 2.4).

Indicators of Livelihoods

- Environmental (Climate, Natural Vegetation, Water sources)
  Rainfall (amounts, distribution and intensity), RFE, NDVI and WRSI
- Livestock
  Species, births, mortality, milk, off-takes (sales and slaughter), household livestock per capita
- Crop;
  Crops grown, condition and harvests
- Markets
  Livestock and grain prices, grain: meat price ratio
- Peoples Welfare
  HH consumption, drought intervention (food for work and cash for work), relief food, migration, conflicts, stock movements, health, IGAs
- Nutrition: Animal and human body condition/health (Box 2.3)

Methods of Assessment of Livelihoods and Food Security

- Food Economy Approach- SCF/WFP
- Turkana District Contingency Planning Unit (TDCPU)-ALRMP
- Livelihoods Approach by USAID-FEWS

2.4 Agrobiodiversity in Nutrition

Nutrients are the building blocks of our body system (Proteins, CHOs, Vitamins, Fats) etc. They are obtained from both plants and animals. People in the developed world are accessible to these in plenty. However, those in the developing countries have scarcity of these nutrients.

Agrobiodiversity is the main source of their nutrients. Agrobiodiversity could be more utilized to improve diets and nutrition. For example, 800 million people are malnourished and two million people lack micronutrients in their diets. A remedy to this is to improve access to a range of crops which are nutritious to all the urban and rural poor. Cropping systems that maintain and use agrobiodiversity have strong potential for improving this accessibility and thus improving nutrition because they are often indigenous, neglected and underutilized food crops and gathered foods rich in nutrients (Table 2.1).

Box 2.3. The Case of Somalia

The humanitarian situation in Somalia is deteriorating at an accelerated pace due to the combination of sky rocketing food prices, a significantly devalued Somali Shilling, a deepening drought following an abnormally harsh dry season and a delayed and poor start to the seasonal rains (mid-April to June), and increasing civil insecurity. As a result, the number of people in need of assistance has increased to ***2.6 million*** (35% of the total population**), which is an increase of more than 40% since January 2008** (up from 1.83 million). This increase is mainly due to the addition of 600,000 urban poor, who now face conditions of **Acute Food and Livelihood Crisis (AFLC) and Humanitarian Emergency (HE).** The number of internally displaced people from Mogadishu has also increased, by 21% since January and is now at 857,000 people, bringing the total number IDPS, both newly displaced IDPs from Mogadishu and the long-term protracted, to 1.1 million people. In addition, the drought is deepening in Bakool and Central regions, pushing a further 60,000 pastoralists into **Acute Food and Livelihood Crisis (GIEWS, 2008).**

Table 2.1. Sources of nutrients from agrobiodiversity

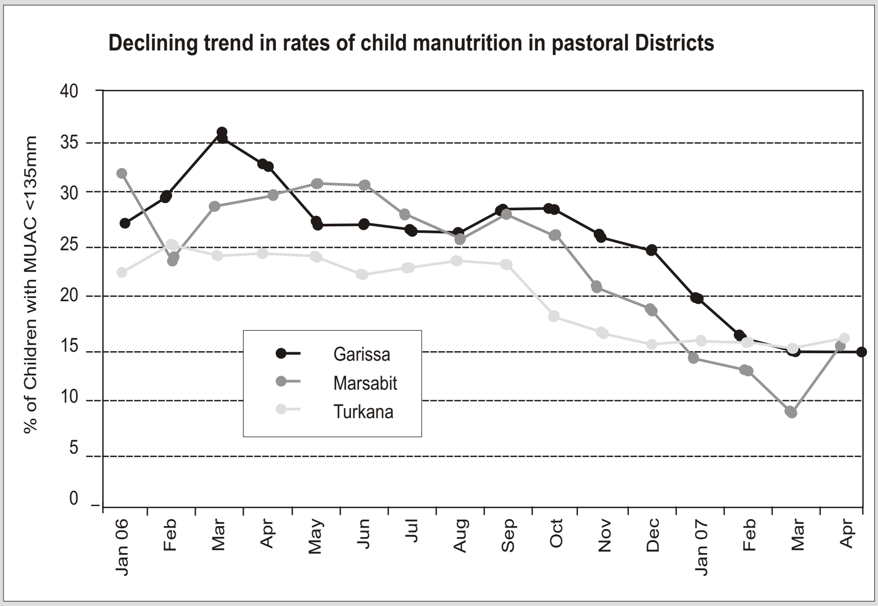
Country	Vegetable	Product
Kenya	Amaranthus (*Amaranthus spp.*)	Vitamins
Brazil	Buriti (Palm fruit- *Maurita flexuosa*)	Vitamin A
Botswana	Drumstick tree (*Moringa oleifera*)	Protein, Iron, Vitamin A

The case of India

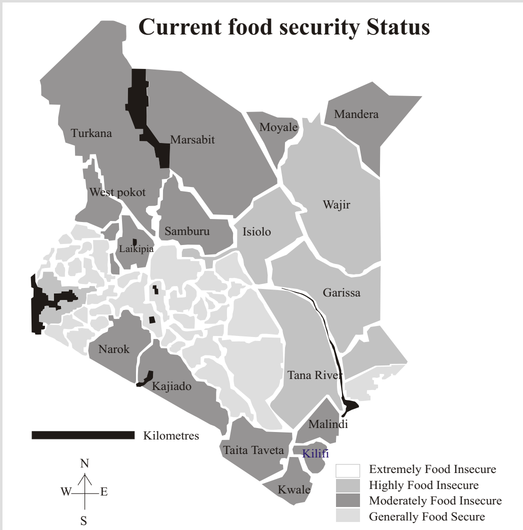
A recent publication, "*Food Insecurity Atlas of Urban India"*, brought out by the M.S. Swaminathan Research Foundation (MSSRF) and the World Food Programme (WFP) indicates that more than 38 per cent of children under the age of three in India's cities and towns are underweight and more than 35 per cent of children in urban areas are stunted (shorter than they should be for their age). The report states that the poor in India's burgeoning urban areas do not get the requisite amount of calories or nutrients specified by accepted Indian Council of Medical Research (ICMR) norms and also suggests that absorption and assimilation of food by the urban poor is further impaired by non-food factors such as inadequate sanitation facilities, insufficient housing and woeful access to clean drinking water. More than 21 per cent of India's urban population live in slums, 23 per cent of urban households do not have access to toilet facilities and nearly 8 per cent of urban households are unable to find safe drinking water (GIEWS,2008).

Box 2.4. The Case of Kenya

"Kenya is edging much closer to a serious food crisis than previously thought. Food production has gone up to four million bags due to better pricing, but projections indicate consumption has risen to 12 million bags."



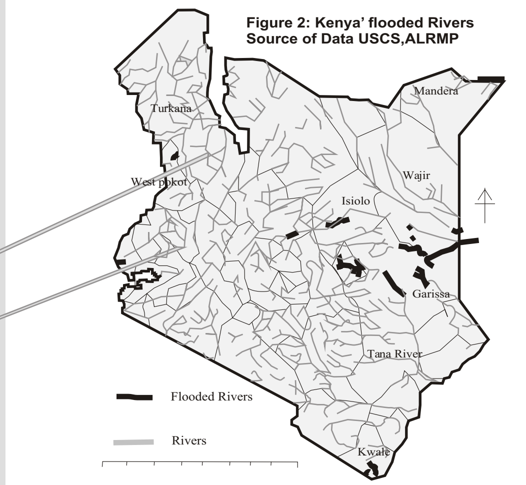
The 2007 long-rains season is now underway after a tentative start in most areas that are outside the Rift Valley, western highlands and the coastal strip. The long rains are critical and are the critical and are the best possible opportunity available to consolidate the beginning of the Recovery process for pastoralists and marginal agricultural households that started toward the end of 2006.The Kenya Food Security Steering Group (KFSSG) is unanimous in the conclusion that substantial, widespread improvements in food security registered at the conclusion of the 2006 short-rains season need to be harnessed through immediate implementation of mitigation and recovery activities. Such activities are intended to consolidate the recovery process and enhance the resilience of pastoral and marginal agricultural livelihoods, in the likely Event that another drought strikes



Source: GOK. ALRMP

The 2006 short-rains season held promise for most of the drought-affected pastoral and marginal agricultural households, after rains started in a timely fashion.

Since then, excessive rains have mitigated the expected improvements in food security, especially in the eastern pastoral areas where the adverse impacts of flooding including displacement of households, upsurge in water and vector borne diseases, limited access to markets, impassable roads and loss of life were accentuated by the Outbreak of the Rift Valley Fever (RVF).



Worked Example

During the SPLA/SPLM war in Sudan in the 1990s, a cattle raid took place at Kapoeta in Eastern Equatorial Region. The raid was mounted by a militia group that supported the Government of Sudan based in Khartoum. They took a number of cattle thus causing a shortage of milk and meat. What remedial measures should be taken to alleviate the resultant food situation?

Scenario I

Before the raid, the Toposa had sufficient food basket of milk/meat (60%), own crops (25%), trade (15%), wild food (5%).

Scenario II

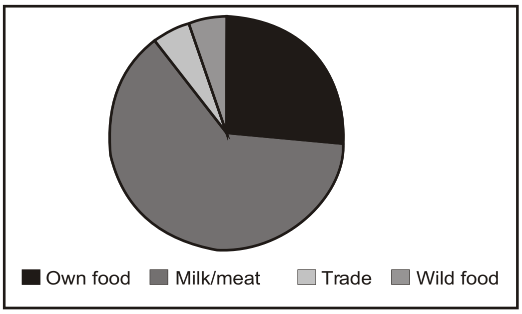
After the raid the Toposa's food basket was as follows milk/meat (40%), own crops (25%), trade (15%) and wild food (5%).

A Deficit 20% was experienced

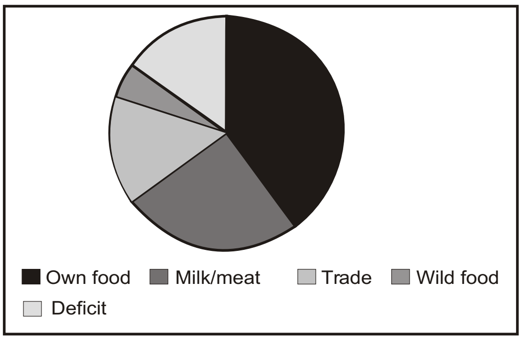
Scenario III

Remedy was a quick response of FOOD AID from NGOs and UN-WFP, Kinship

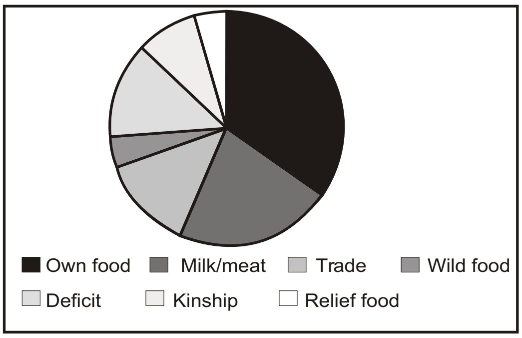
SCENARIO I



SCENARIO II



SCENARIO III



Scource: USAID-FEWS NET

2.5. Key Points

- Agrobiodiversity is essential in attempts to attain food security
- Traditional agricultural systems should be an integral part of modern agriculture systems
- Diversification of farm enterprises should be promoted by all means
- Coping mechanisms should always be there in case of food threats and shocks
- Food security is achieved when food is of high quality, safe and nutritious
- Food insecurity is mitigated when there is an emergency and disaster preparedness Programme

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Exercise I

During the winter of 2003 the floods in Mozambique caused crop failures in many parts of the country and many animals died. A food deficit of 40% was experienced. Draw pie-charts to demonstrate how the people coped with the floods.

Exercise II

1. In Zimbabwe, White Corn Farms which produced 50% of the country's food basket were raided in 1999. The following year there was a shortage of 15% corn. The rest of the food basket containing 10% trade, 15% wild food and 30% meat/milk remained the same. Draw pie charts to show how the citizens coped with this scenario.
2. Can we say we are food secure in Africa?

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Module 3: Ownership of Agrobiodiversity and Local Knowledge

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3.0 Learning Objectives

By the end of this module, the learners will understand;

i. The debate on ownership of agrobiodiversity;
ii. Legal frameworks of agrobiodiversity;
iii. Geographical distribution of agrobiodiversity; and
Iv. Local knowledge and agrobiodiversity;

3.1 Agrobiodiversity and Ownership

For centuries, reproduction of crops was controlled by farmers and food producers in their communities. Seeds for the next season's crops were retained from harvests and exchanged between communities. Selection techniques which were integrated with annual crop cycle were used to adjust varieties to changing agro-ecological conditions and processing requirements.

In the past 200 years, various institutions (Private sector companies, National/International, NGOs) have evolved with an interest in collecting, conserving and improving these genetic materials. These institutions obtained plants and seeds freely from peasant farmers and other rural people in the developing countries, which was a germplasm that is "common heritage of mankind", a public good for no payment (Winkies, 1983, Joske et al. 1996).

The concentration of seeds, cuttings and whole plants in gene banks or botanical gardens being administered by scientists, mostly from the North is the bone-of-contention. The free of charge of these germplasm has made it possible for the germplasm to be found in the hands of professional breeders in the private sector companies of industrialized countries. Here, it has acquired a monetary value which in most cases is greater than its value to the resource-poor farmer. Farmers are interested in the use value of germplasm but professional private breeders are interested in the exchange value of germplasm (return on investments). Hence, the plant breeders rights (PBRs) body has been formed. The body advocates for payment for the varieties developed by them because of the value addition they have done. Other breeders are exempted from payment.

However, with the emergence of modern biotechnology companies, the above arrangement has been put under pressure. The breeding companies are now unwilling to share results of their research. They argue that the concept of value adding entitles them to charge all users for their products and withhold information and materials from potential competitors. These companies are using biotechnology as a way of increasing farmers' dependency on them. The traditional farmers and processors in developing countries are affected most (Joske et al., 1996).

The ownership, control and exchange of plant genetic resources for food and agriculture (PGRFA) are more complicated as one has to deal with numerous laws, regulations, guidelines and policies formulated by national and international fora. Such fora include Food and Agriculture Organization (FAO), Convention on Biological Diversity (CBD), World Trade Organization (WTO), and World Intellectual Property Rights (IPR) organization among others. This complex and contentious bio-political environment (on who owns what) has led to a new language that did not exist 25 years ago. The new language now includes terms like genetically modified organisms (GMOs), Bio piracy, Farmers' rights. This has led to the development of protection framework of AGBD ownership and governance. The scope of the agreement is broad, applying to copyright and related rights, trademarks, geographical indications, industrial design, patents, the layout designs of integrated circuits, and undisclosed information such as trade secrets and test data.

Rapid developments in the field of biotechnology have also increasingly drawn attention to the issue of intellectual property rights in relation to animal genetic resources (AnGR). The prospect of patents being applied to livestock genes, genetic markers or methods for genetic improvement has given rise to much controversy. The issue potentially has substantial implications for the management of AnGR and PGRs and access to the benefits arising there from.

3.2 Legal Frameworks in the Management of Agrobiodiversity

The frameworks include both legally binding and nonbinding instruments. The non-binding legal instruments (sometimes called "soft law"), are utilized for a variety of reasons, including strengthening member commitment to agreements at the policy level, reaffirming international norms, and establishing informal precedents for subsequent treaties.

UN conferences

Agenda 21, adopted in 1992, is a plan of action to be undertaken at the global, national and local levels by governments, the organizations of the United Nations System and other stakeholders, to address all areas of human impact on the environment. The Agenda was prepared to coincide with the 1992 United Nations Conference on Environment and Development (Earth Summit) held in Rio de Janeiro, and was adopted at the time by 179 governments. Chapter 14 of Agenda 21, "Promoting Sustainable Agriculture and Rural Development', addresses the question of increasing food production in a sustainable way and enhancing food security. Among the programme areas included in Chapter 14, is programme area (h) on the conservation and sustainable utilization of AnGR. The management related activities specified in this programme stipulate that governments should draw up breed conservation plans for endangered populations, including semen/embryo collection and storage, farm-based conservation of indigenous stock and *in-situ* conservation, b) plan and initiate breed development strategies, and c) select indigenous populations on the basis of regional importance and genetic uniqueness, for a ten-year programme, followed by selection of an additional cohort of indigenous breeds for development." This also applies to plant genetic resources (PGRs).

Subsequently, at the World Summit on Sustainable Development held in Johannesburg in 2002, sustainable agriculture and rural development was one of the issues considered in the Plan of Implementation. Paragraphs 6(i) and 38 of the Final Declaration stress the importance of sustainable agriculture and rural development to the implementation of an integrated approach to increasing food production and enhancing food security and food safety in an environmentally sustainable way.

Convention on Biological Diversity (CBD)

The Convention on Biological Diversity (CBD), a legally binding international framework for the management of biodiversity, was signed by 150 governments at the Rio Earth Summit. By 2005 it had 188 parties. The three objectives of the CBD, as set out in Article 1, are: the conservation of biological diversity, the sustainable use of components of biological diversity, and the fair and equitable sharing of the benefits arising from the utilization of genetic resources. Conservation of animal and plant genetic resources required for food and agriculture is addressed by its programme of work on agrobiodiversity. The CBD states that, while states have the sovereign right to exploit their own resources (Article 3), they also have the duty to conserve them and to facilitate access for sound uses to other contracting parties (Article 15). The need for policy development and integration is acknowledged in the CBD, and governments are requested to develop national strategies on biodiversity (Article 6a), and to integrate "the conservation and sustainable use of biological diversity into relevant sectoral and cross-sectoral plans, programmes and policies" (Article 6b). The special nature of agricultural biodiversity has been consistently recognized by the Conference of the Parties (COP) to the CBD.

The Commission on Genetic Resources for Food and Agriculture (CGRFA) was the first permanent intergovernmental forum dealing with agricultural genetic resources. At present, 167 Governments and the European Community are members. Other players in the protection of agrobiodiversity include; 1) General Agreement on Tariffs and Trade (GATT) in 1947. Under GATT, patents and intellectual property rights have been viewed as important political instruments in connection with the market economy and its liberalization, 2) World Trade Organization (WTO) was created in 1995 by GATT to implement and administer GATT trade agreements, 3) Agreement on Trade-related aspects of intellectual property rights (TRIPS) was created to provide that signatory states to GATT/WTO must integrate the provisions of the TRIPs agreements into their national legislation. The agreement allows trade restrictions as the final consequence of a violation of the provisions, 4) Union for the protection of new varieties of plants (UPOV) is a multi lateral agreement by plant breeders to mutually recognize landraces and protect property rights to plant varieties at national level. This accord prohibits farmers from selling derived varieties from their own harvest and from certified varieties and 5) Non-Governmental Organizations like;

(i) Third world net work,
(ii) Rural Advancement Fund International
(iii) Genetic Resources Action International (GRAIN)

In summary, the globalization of the food systems and marketing has led to less cultivation of plant varieties and breeds of animals because of the formulated rules on patenting, international property rights (IPR) and the living organisms. This has led to less diverse and a more competitive market; hence there are changes in farmer's and consumer's perceptions, preferences and living conditions. There is marginalization of small-scale, diverse food production systems that conserve farmers' varieties of crops and breeds of domestic animals, and also reduced integration of livestock in arable production, which reduces the diversity of uses for livestock and there is reduced use of "nurture" fisheries techniques that conserve and develop aquatic biodiversity.

Access and benefit-sharing of agrobiodiversity

Farmers need formal recognition for the preservation, development and improvement of plant and animal genetic resources. This formal recognition forms the corner-stone for the demand on the international community to provide future financial support for these activities. Local community and indigenous groups should be considered on investment in preservation and future use of biological resources.

Conventional Biological Diversity (CBD) has put laws to bind or protect rights of farmers to dispose off their own biological diversity. These include Plant Genetic Resources (PGR) and animal genetic resources. This will be good for developing countries as each country will be responsible for disposition of rights to genetic and biological resources. This is seen as a legal right of ownership. However, it should also provide regulated access to these resources. As a counter measure, appropriate share of potential profits from the use of these resources should be assured. What remains unregulated is how those varieties and samples collected before the adoption of the convention (which are being stored in large quantities in gene banks or in botanical gardens) are to be treated in terms of ownership rights and benefit sharing.

The role played by indigenous peoples and their knowledge in both creation of future preservation and use of genetic resources should be recognized by having a share in the profits and benefits attained from their use. The developed and developing countries should protect and support the utilization of traditional methods together with modern preservation of biological diversity. In developing countries, some of the traditional local practices in dealing with genetic resources are automatic exchange of seed, sire and products and the passing on of knowledge regarding special properties of plants, animals, microorganisms and annual products. At present, these are in conflict with "developments" in developed countries due to;

(i) patents
(ii) intellectual property rights
(iii) ownership framework

Some steps have been taken in this direction, World Trade Organization (WTO) has been created and agreements reached on Trade Related Property Rights (TRIPS). Hence, some organizations are against the reducing of benefit sharing because of the commercial approach. Some policy issues in AnGR and PGRs management that are being discussed in relation to agrobiodiversity ownership are patenting and farmer's rights.

Patenting

Intellectual property rights (IPRs) are granted in order to provide innovators with a greater opportunity to capture the benefits arising from the products of their inventiveness. The need for IPRs can be justified in economic terms as a means of overcoming a characteristic of market economies which tends to reduce the rate of innovation below the social optimum when innovations can be copied freely. Moral arguments in favour of IPRs can also be put forward, related to the justice of rewarding those whose work results in useful innovations (Evans, 2002). However, these two general justifications are seldom tested with empirical data to find whether there is actually a need for stronger IPRs to stimulate research and development in a particular field of innovation.

Other forms of IPR are of potential relevance to the management of AnGR and PGRs, particularly trademarks, trade secrets and geographic indications. The holder of a trademark is given exclusive rights to use a name or symbol associated with a product. The goodwill that the holder has built up while providing the product under a given name cannot then be expropriated by others or dissipated through the supply of inferior products under the same name (Lesser, 2002).

An example would be Certified Angus Beef ® protected by federal trademark law in the United States of America. Similar to trademarks are rights to geographical appellations of origin, which indicate that a product was produced in a particular geographical area where the production conditions are associated with distinct characteristics. These rights are of considerable relevance to niche markets, and hence potential to the utilization of local livestock breeds or plant varieties. Trade secrets relate to the protection from misappropriation of any commercially sensitive information (and materials) that the holder takes reasonable precautions to conceal.

Crop breeders have for many years used this approach to protect the parent lines and related information used in the production of hybrid seed for sale, and similar approaches are adopted in the poultry and pig industries (Lesser, 2002). Plant breeders' rights (PBRs) have been developed to protect the IPRs of plant breeders. PBRs offer a protection that is adapted to the agricultural sector, and include certain levels of exemption for further breeding and for farmers to retain seed from the crop. An internationally harmonized framework for the management of PBRs is established under the auspices of the International Union for the Protection of New Varieties of Plants (UPOV). In the case of patents, the holder is given exclusive rights over the commercial use of an innovation for a set period of time, often 20 years, in the country in which the patent is granted. In order to obtain a patent, the innovation must be inventive or not obvious; and it must be novel, in the sense of not being previously known through public use or publication (Lesser, 2002). A patent can be obtained to cover, a product *per se* (in itself), a process, or a product derived through a process; it may be dependent on previous patents.

While patents may serve to promote innovations, it must be recognized that once a new product has been developed, the existence of a patent inhibits competition and thereby reduces the availability of the product.

Institutional Frameworks

Institutions that have a clear mandate and function well are the backbone of the implementation of laws and policies. A basic institutional structure is essential for the coordination of strategies for AnGR and PGRs management. Clear legal definitions of institutional roles are important. Complicated or unclear arrangements may cause problems for coordination and communication between stakeholders. Frameworks vary between countries according to the characteristics of national administrative systems, the availability of financial resources, and the overall economic and social conditions.

3.3 The Kenyan situation on patents

In Kenya three government ministries administer intellectual property rights. Kenya Industrial Property Institute (KIPI), a body corporate in the Ministry of Trade and Industry administers the Industrial Property Act 2001 of the laws of Kenya covering Patents, Trademarks, Service marks, Industrial designs and Utility models. Copyright is administered by the Copyright Board of Kenya an office in the Attorney General Chambers under the Copyright Act 2001 of Kenya. The Plant varieties Act of Kenya is administered by the Kenya Plant Health Inspectorate Services KEPHIS.

Intellectual property is protected by national laws, which are unique in each country. Some countries including Kenya have become signatories to multinational treaties and agreements, which provide some form of harmonization in the protection of intellectual property. Kenya is a member of the following organizations, protocols, treaties and agreements:

a. World Intellectual Property Organization (WIPO)
b. African Regional Intellectual Property Organization (ARIPO)
c. Trade Mark Law Treaty- now Singapore Treaty on the Law of Trademarks since 28th March 2006.
d. Paris convention for protection of Industrial Property.
e. Madrid Union (Madrid Agreement & Protocol) on International Registration of Marks.
f. We are about to join Nice Agreement on classification of Trade and Service Marks.
g. We use Vienna Classification although not members of Vienna agreement (There is provision in Trademarks Act for both Nice and Vienna classifications)
h. Patent cooperation treaty PCT
i. Berne convention on Copyright
j. Nairobi Treaty on the Protection of the Olympic Symbol
k. UPOV for New Plant varieties
l. Trade Related Aspects of Intellectual Property Rights (TRIPS).

Kenya's existing intellectual property legislations have been drafted in line with those provisions

Rights Conferred

The owner of the intellectual property right has the right to preclude any person from exploiting the protected property by any of the following acts

- Making, importing, offering for sale, selling and using the property; or
- Stocking such product for the purposes of offering it for sale, selling or using the .

In return for the grant of a patent for example, the inventor places the technological information surrounding the invention in the public domain. This is achieved by publishing a patent document. Any invention, which is not protected in a given country, is considered as being in the public domain in that country. Such invention could be used in that country for its own technology development without the risk of infringement. The duration of a patent is usually limited to twenty years. Once this period has expired, all third parties may use the information and thus exploit the invention.

Protection Procedures

Inventions

A patent is granted by a national patent office or by a regional office that does the work for a number of countries, such as the European Patent Office (EPO). At the Institute applications to grant patents are received from four routes, namely:

- Local
- ARIPO
- PCT (World intellectual Property Organization-WIPO)
- Foreign - direct

A patent describes an invention for which the inventor claims the exclusive right.

Invention is a new solution to "technical" problem. (Product, process and new use)

- It must be new
- Have an inventive step
- Be Industrially applicable

Application Procedure for a patent

- Application (Application Form, Application fees, Patent document, Power of attorney if represented by agent)
- Patent document (Title, field of technology, background art, brief description, detailed description together with drawings, claims, and an abstract)
- Search/Substantive examination
- Publication
- Grant
- Priority 12 months

Utility Model

A utility model is an invention that can be utilized in industry, agriculture, education services or environmental conservation and which relates to shape, structure or assemblages of articles.

- It must be new
- Be Industrially applicable

Industrial Design

Industrial design is the ornamental or aesthetic aspect of a useful article of industry. Design is the aspect that gives special appearance to a product of industry.

Application Procedure for an Industrial Design

- Application form
- Application fees
- Representation of the design (photo, drawing etc)
- Comparison with existing designs
- Publication (opposition period 60 days)
- Registration
- Priority 6 months

Trademarks

A trade mark is a registered design or name used to identify a manufacturer's goods.

Trademarks have become more and more important in recent years. Kenya Industrial Property Institute, the official body for registration of trade and service marks in Kenya, is mandated by the Trademarks Act Cap 506, (As last amended by the Trade Marks (Amendment) Act, 2002), of the Laws of Kenya to give protection to trademarks and service marks.

A trade mark can take many forms. The law states that a trade mark may be any symbol that is capable of identifying a company's goods or services. It can be a word, a picture or a combination of both. For example "PHILIPS" is protected as a word trade mark. An example of a picture protected as a trade mark is BP Shell's red and yellow seashell. The name "*Florida Casino*" together with the stylized (letters in italics) is a combined trade mark comprising a word and a picture.

Colours (think of the yellow Kodak trade mark), combinations of numbers and letters (such as Q8, 4711, AKZO) and drawings or shapes (such as the Adidas stripe or the Coca-Cola bottle) are also considered trademarks.

It is impossible to imagine life today without trademarks. Not only are trademarks necessary to differentiate products or services from each other, but often they have an important expressive or even emotional value as well. The use of trademarks is particularly important in advertisement as a strategy for marketing.

Trademarks help consumers to distinguish the products of one proprietor from those of others in the market place. More usually they associate the trade mark with the reputation (quality) of goods emanating from the proprietor. Creating a product usually involves major investments, hence the need for the product to be protected. The Trade Marks Act helps the producer protect the trade mark. Registering a trade mark is an important first step for everyone towards safeguarding a Trade mark and combating imitations. Application for registration of a trade mark can be done directly at the Institute or at the place of a trade mark specialist authorized as a representative.

Application procedure for registering a Trademark

- First of all, the applicant must request the relevant application forms. The forms are obtained free of charge from our Institute and should be completed in English language.
- Completed forms can be submitted in person or by mail. The necessary information and fees payable are supplied along with the forms.
- The Institute checks the completeness and accuracy of the information entered and documents submitted.
- In a few weeks the applicant receives the results of the search or examination.
- If the trade mark is available for registration upon examination, it is approved for advertisement in the Industrial property Journal to allow for any opposition, within a period of sixty days from the date of the Journal.
- If there is nobody challenging the intention to register the advertised trade mark, the trade mark is registered and the applicant is issued with a Certificate of Registration.

An entry in the Institute's Trademarks Register is valid for ten years from the date of the application. Three months before the validity lapses, the trade mark holder is notified in writing to this effect so that an application for renewal can be made in good time for another set of ten-year period. Trade mark protection is indefinite as long as it is renewed.
The Office can refuse to register certain trademarks, for example in cases where these contain purely descriptive elements (e.g. “tasty Cheese” for daily products or “life insurance” for life insurance). Or even on moral grounds.

Protection abroad

Currently there is an international agreement formed by two treaties, the Madrid Agreement and the Madrid Protocol, both being referred to as the Madrid System, with the present membership of about 78 countries, Kenya inclusive. This makes it possible for one to apply for protection in some or all of those countries by a single application. Such application is submitted through Kenya Industrial Property Institute as a receiving office, for transmission to the International Bureau of the World Intellectual Property Organization in Geneva, Switzerland.

Copyrights

Registration of copyright is based on non-formality provision under the Bern Convention of 1883 for protection of literary and artistic works. Copyright protection is borne by simply expressing the original idea in a fixed form. However, many countries provide for a national system of optional registration and deposit of works; these systems facilitate, for example, questions involving disputes over ownership or creation, financing transactions, sales, assignments and transfers of rights.
Kenyan copyright office is also considering the possibility of putting in place some form of a procedure before it would cater for the interest of those creators who demand some symbolic document to signify a protection.

In general, IPR still has new approaches being put forward. At both national and international level, legal and institutional arrangements to safeguard the interests of the various parties involved will still continue for some time. Small farmers producing for local markets will still be hampered by legal and institutional reforms. This is because it is unlikely that the companies or governments in developing countries will be able to set up viable systems for monitoring small farmer's compliance with IPR, or enhancing on the concept of farmers' rights on serious problems of establishing who owns what and determining who is acting on whose behalf (Joske, et al 1996).

3.4 Geographical Distribution of Genetic resources

Nowadays, much diversity can no longer be found in farmers' fields or in the wild. Much diversity can now be accessed from gene banks far removed from a centre of origin. Germplasm transfers from *ex-situ* collections in public domain form the major source for both developed and developing countries. This means that access from *ex-situ* sources exceeds access from *in-situ* conditions. The stakeholders in access are the plant breeders (very critical) and farmers who must use improved seeds or sire lines.

Therefore, no single country relies only on indigenous crops or animals or genetic resources sourced locally but they all need access to genetic resources for agricultural production and food security.

All genetic resources originally came from *in-situ* conditions. This is germplasm conservation that involves leaving species in their natural habitat, allowing adaptation and evolution to continue. This constitutes habitats that are farmed traditionally. Currently, much of the genetic diversity can no longer be found in their natural fields or habitats but are found located in various centres of the world in gene banks (Table 3.1). This type of conservation is called *ex-situ*. It involves storage of germplasm under controlled conditions of temperature and humidity. This is particularly the case for major stable crops like rice, maize and wheat. FAO estimates that 95% of the landraces of these crops is found in *ex-situ* (Table 3. 1).

Table 3. 1. State of the world's plant genetic resources for food and agriculture

Region	No. of Accessions	% of Total	Gene Banks	% of Total
Africa	353523	6	124	10
Latin America and Caribbean	642405	12	227	17
North America	762061	14	101	8
Asia	1533979	28	293	22
Europe	19345744	35	496	38

Source: FAO 1998.

For animal genetic resources, the gene flow has no systematic records of breed population sizes. If any, the breeds in temperate zones are often better defined and documented than breeds from tropical regions and marginal areas. Gene flows within large countries do not show up in the international statistics. In contrast to plant genetic resources, there is no quantitative share of gene introgression (FAO, 2007).

Barriers in AGBD access and benefit sharing

(i) Access and benefit sharing is a major issue in the discussion of plant genetic resources, but not yet in farm animals genetic diversity.

(ii) Clear and practical guidelines on AGBD access and benefit sharing are not available. They Remain a major conflict between the providers (Farmers and Breeders) and users of AGBD

(iii) The CBD does not make any provisions for benefit sharing.

3.5 Local Knowledge and Agrobiodiversity

Local knowledge is the information people in a given community have developed over time. It is based on experience, adapted to local cultures and environment and is continuously developing. This knowledge is used to sustain the community, its culture and maintain the genetic resources necessary for the continued survival of the community. Sometimes it is referred to as traditional knowledge or indigenous knowledge, thus it embraces a larger body of knowledge systems.

Knowledge systems are dynamic and people adapt to changes in their environment and take up ideas from various sources. However, knowledge and access to knowledge are not distributed evenly in a community or between communities. People may have different objectives, interests, perceptions, beliefs and access to information and resources. Knowledge is generated and transmitted through interaction within specific social and agro-ecological contexts. It may be linked to access and control over power. Differences in social status can affect the perception and access to knowledge. Knowledge possessed by the rural poor, in particular the women, is normally overlooked and ignored.

Local knowledge includes:

(i) mental inventories of local biological resources

(ii) animal breeds

(iii) local plant, crops and tree species

(iv) information about trees and plants that grow well together or indicator plants that show soil salinity or known plants that flower early at the beginning of rains.

(v) practices and technologies such as seed treatment and storage methods, tools used for plants and harvesting and tools used for castrations and other animal husbandry practices.

Local knowledge encompasses belief systems that play a fundamental role in people's livelihoods, health, protection and conservation of the environment. Local knowledge is collective in nature and it is a property of the entire community and does not belong to any single individual. There are three types of knowledge;

(i) Common knowledge:	Held by most people in a community, for example, everyone knows how to cook local staple food.
(ii) Shared knowledge:	Is held by many but not all community members, for example, villagers who raise livestock will know basic animal husbandry than those without livestock.
(iii) Specialized knowledge:	Is held by a few people who might have had specialized training or an apprenticeship, for example, only few villagers will become healers, midwives or blacksmiths.

The type of knowledge people have is related to their age, gender, occupation, labour division within the family, enterprise of a community, socio-economic status, experience, environment, history, among other factors. This type of knowledge is dynamic and changes over time as the environment also changes. This makes it difficult to decide whether a technology or practice is local, adopted from outside or blend of local and introduced components. Therefore, one has to look at what is in the local community then make a decision on the type of information that would be more relevant to the specific situation. Most likely, it will be a combination of Different knowledge sources and information types.

Box 3.1: Wild-food Plants in Southern Ethiopia

The rural people of Ethiopia are endowed with a profound knowledge of the use of wild plants. This is particularly true for medicinal and wild plants, some of which are consumed during drought, war and other hardship. Elders, and other knowledgeable community members, are the key sources or reservoirs of plant knowledge. Wild-food consumption is still very common in the rural areas of Ethiopia, particularly for children. Among these, the most common wild plant fruits consumed by children are from the plant species *Ficus spp*., *Carissa edulis* and *Rosa abyssinica*. The consumption of wild plants seems to be more common and widespread in food insecure areas, where a wide range of species are consumed. The linkage has given rise to the notion of famine-foods, plants that are eaten only at times of food stress and that are therefore an indicator of famine conditions. Local people know of the importance and the contribution that wild plants make to their daily diet. Also, they know of the possible health hazards, such as an upset stomach that may occur after eating certain wild plants. For example, *Balanites aegyptiaca* (*bedena* in Amharic), an evergreen tree, about 10 to 20 m tall, is typical of this category. Children eat its fruit at any time when ripe, when there are food shortages they will be eaten by adults. The new shoots, which are always growing during the dry season, are commonly used as animal forage. Although, during food shortages, people cut the newly grown succulent shoots and leaves, which are cooked like cabbage. People in the drought-prone areas of southern Ethiopia also apply these consumption habits to the fruits and young leaves of *Solanum nigrum* (black nightshade), a small annual herb, and *Syzygium guineense* (water berry tree), which is a dense, leafy forest tree around 20 m tall. In parts of southern Ethiopia, the consumption of wild-food plants seems to be one of the important local survival strategies. This appears to have intensified because of repeated climatic shocks that have hampered agricultural production, leading to food shortages. Increased consumption of wild-foods allows people to better cope with erratic, untimely rains. They are able to face several consecutive years of drought, without facing severe food shortages, famine and general asset depletion, as is the case in other areas of Ethiopia. The key to this survival strategy is the collection and consumption of wild plants. These are found in uncultivated lowland areas such as bush, forest and pastoral land. In the more densely populated, and intensively used mid and highlands, a great variety of these indigenous plants and trees have been domesticated for home consumption and medicinal use. Southern Ethiopia, particularly Konso, Derashe and Burji special *weredas* and parts of the southern nations, nationalities and people's region (SNNPR) may still be considered part of these biodiversity hot-spots in Ethiopia. (FAO, 2006)

Importance of local knowledge

Local knowledge is the human capital, both in the rural and urban people. It is the main investment for food production, provision of shelter and livelihood control. Local knowledge is developed and adapted continuously to a changing environment. It is passed down from generation to generation and is interwoven with people's cultures.

Today, local knowledge is on the brink of extinction. This is due to the rapidly changing natural environments and the rapid economic, political and cultural changes. However, many practices disappear because of introduction of foreign technologies or development concepts that promise short term gains or solutions to problems. This is a problem to the rural poor who have developed the knowledge to use for intervention during times of need, for example wild fruits being used as food during food shortage periods (Box 3.1), or using herbs for medicinal purposes for either veterinary or human diseases.

Local knowledge is of particular relevance to the following sectors;

(1) Agriculture

(2) Animal husbandry and ethnic veterinary medicine

(3) Use and management of natural resources

(4) Health care

(5) Community development and

(6) Poverty alleviation

Examples of local knowledge and agrobiodiversity that have been put in place;

i) Use of local knowledge for bio-processing (case of drug development).

ii) Use of indigenous edible species of plants to enhance health.

iii) Traditional ethno-veterinary medicine.

iv) Policies related to farmer's rights to protect knowledge related to plant and animal genetic resources for food and agriculture.

Limitations to building on local knowledge

(i) Local knowledge is not equally distributed across the community.

(ii) Local knowledge is not necessarily freely communicated.

(iii) Local knowledge is not easily accessible and understandable to outsiders. It should not be extracted from individuals/communities: It should be explored and shared in a participatory fashion.

(iv) Local knowledge is often regarded as inferior to "Western" knowledge. There is a vacuum at policy level where it does not contribute to decision-making.

(v) Local knowledge does not necessarily offer a solution to changing external conditions.

3.6 Key points

- Local knowledge is developed over time by people living in a given community, and it is continuously developing.
- Knowledge systems are dynamic, people adapt to changes in their environment and absorb and assimilate ideas from a variety of sources.
- Knowledge and access to knowledge are not spread evenly through a community or between communities; people have different objectives, interests, perceptions, believes and access to information and resources.
- The type of local knowledge people have is related to age, gender, occupation, labour division, social-economic status, their experience, environment and history.
- Local knowledge is the human capital of the rural and urban people, it is the main asset they invest in the struggle for survival to produce food, provide for shelter or achieve Control of their own lives.

Exercise

To be done in three groups

1. Relate agrobiodiversity ownership with our policies in the agriculture sector by examples of Policies that protect AGBD if any.
2. Identify the weaknesses in policy that deny the local farmer to benefit from the sharing of profits from research on germplasm that came from *in-situ* that are now in *ex-situ*.
3. Explain how local knowledge is being utilized in the preservation of AGBD in the current practice of agriculture in our country.

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Module 4: Agrobiodiversity and Gender

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4.0 Learning Objectives

At the end of the module, the trainees should be able to:

i. Understand the concept of gender and how it relates to agrobiodiversity management; and
ii. Identify and appreciate the roles of men and women in agrobiodiversity management

4.1 Definition of Gender

Gender refers to the social roles and relations between women and men which are socially constructed, and can change and vary over time and according to geographic location and social context. Gender is not determined biologically but is socially constructed. It is a central organizing principle in societies, and often governs production and reproduction, consumption and distribution. Gender relations affect household security, family wellbeing, planning, production and many other aspects of life.

4.2 Gender Roles and Gender Relations

Gender roles are the roles defined for men and women in a given society. They vary among different societies and cultures, classes and ages and during different periods in history. In all societies, men and women play different roles, have different needs and face different constraints. Gender roles differ from biological roles of men and women, although they may overlap. For example, women's biological roles in child bearing may extend their gender roles to child rearing and, cooking of food, and household maintenance.

Gender specific roles and responsibilities are often conditioned by the household structure, access to resources, decision making authority and other locally relevant factors such as ecological conditions. These roles change with social, economic and technological change. For example, factors such as introduction of new crops and technologies, increased pressure on land, or increasing poverty, conflicts and migration can change the roles of men and women in agriculture.

In agriculture, women are actively involved in production in most countries. However, men's and women's roles differ widely across regions. Among some groups, women are involved in weeding, harvesting, and storage of crops while men plough the land. In other cases, men also weed the farms. There are several factors that influence gender-based differences. These may be social and economic factors that can reinforce or decrease gender based disparities. These factors include:

Institutional arrangements: These create and reinforce gender-based constraints or conversely, foster an environment in which gender disparities can be reduced. For example, where women primarily grow food crops, institutions providing agricultural credit for food production can either promote or discourage women's access to credit.

The formal legal system: This reinforces customary practices and gives women inferior status in many countries. Women are discouraged, and in some countries legally barred from owning land, property and other agricultural assets; opening bank accounts; or contracting for credit in their own names.

Socio-cultural attitudes and ethnic and class based obligations: These affect farming systems and determine which crops men and women grow, the type of farm mechanization used on the land they grow crops, livestock vaccinations or whether women need their husbands' approval to sell their cattle or farm produce.

***Religious beliefs and practices*:** These limit women's mobility, social contact, access to resources, and the types of activities they can pursue. Some interpretations of religious law, for example, often stipulate gender-based differences in inheriting land.

In general, each society has its norms and rights as it assigns various gender roles. This is collectively referred to as gender relations.

Gender relations are the ways in which a culture or society defines rights, responsibilities, and the identities of men and women in relation to one another. There are five key components of gender relations analysis: gender roles; gender division of labour; access to resources, power relations and gender needs (Box 4.1).

Gender roles arise from socially perceived differences between men and women that define how men and women think, act and feel. They are an integral part of social identity and belonging. Gender roles may be categorized into four types of activities: reproductive, productive, community managing and constituency based political roles. The nature and extent of individuals' involvement in each activity reflects the gender division of labour in a particular place at a particular time. The roles of being a mother or father, for instance incorporate the right and obligation to care for children and to provide a living for the family. If the related behaviour is not observed, society withdraws its approval.

Gender division of labour relates to the different work men and women do as a consequence of their socialization and accepted patterns of work within a given context.

Access to resources, benefits, information, and decision-making are all influenced by acceptable gender roles and the established division of labour.

Power relations have to do with the capacity of individuals and groups to initiate action and determine outcomes which change existing social, political and economic systems and norms, to equalize gender relations.

Since men and women have different types of work, different degrees of access to services and resources, and experience unequal relations, the needs of men and women are different. There are practical (immediate and material arising from current conditions) and strategic gender needs (long term related to the positions of women and men, and focus on equalizing gender-based disparities in wages, education and employment).

Rural people's roles as food producers and food providers, link them directly to the management and sustainable management of agrobiodiversity. Through their daily work, rural people have accumulated knowledge and skills concerning their ecosystems, local varieties, animal breeds, agricultural systems and the nutritional values of various underused crops. Men and women act differently because of their socially ascribed roles, therefore, they have different sets of knowledge and needs. Lack of recognition of the different needs of men and women can negatively impact on agrobiodiversity conservation.

Box 4.1: Gender preferences in growing of traditional leafy vegetables in Kenya
In Bondo district in Kenya, growing of traditional vegetables is associated with low income status of the family in the community. The vegetables, include, cowpea (*Vigna unguiculata*), black night shade (*Solanum scabrum*), *Crotalaria spp* and spider plant (*Cleome gynandra*). Women are the ones who grow traditional vegetables, mostly as kitchen gardens, especially if the rains are low. The women exchange seeds and they know which seed to use (based on length of storage, colour and hardness). They normally grow these vegetables for income generation. They sell to buy household requirements like salt, soap, cooking oil and paraffin for house lighting among others. Older males focus on growing of maize and raising livestock to earn a living. Young males have resorted to growing of exotic vegetables and fruits like cabbage, kale and water melon (*Mungai et al., 2008)*.

4.3 Gender Mainstreaming

Gender mainstreaming is the process of assessing the implication for women and men of any planned action. It is integrating women's and men's concerns and experiences in the design, implementation, monitoring and evaluation of policies and programs in all political, economic and social spheres so that both will participate and benefit equally. Development responses will be more equal, efficient and sustainable when gender is mainstreamed in agricultural biodiversity conservation strategies. Societies that discriminate on the basis of gender pay a significant prize in terms of increased poverty, slower economic growth, weaker governance and lower quality of life. It has also been noted that women are intimately linked to the environment because of their concern for their communities and for future generations. It has also been argued that women stand at the core of the sustainability paradigm. In order to design sustainable development policies and projects, it is crucial that the different roles of men and women are understood for sustainable implementation of activities.

A gender perspective helps identify and address the practical and strategic needs of women and men, thus ensuring project relevance and impact. It also helps to identify gender-based inequalities and to formulate strategies and activities to overcome them. Since gender relations are socially constructed, they can be changed. Development and conservation agents have a responsibility to influence and support the transformation of communities towards more democratic and equitable societies.

4.4 Gender in Agrobiodiversity Conservation

Some key areas where gender makes a difference in the conservation of agricultural biodiversity

Role in seed selection

The gender factor in seed selection varies. In some areas, women are involved in the selection, improvement and adaptation of plants while in other areas, this task is entirely assumed by men. Women have more knowledge of wild plants used for food, fodder and medicine than men. In other cases, shared responsibility exists; men and women may be responsible for different crops or varieties. Sometimes, men and women may have different tasks related to the same crop or varieties, or be responsible for different tasks related to one crop.

Access to resources

Because of their shared responsibilities, women are more often responsible for subsistence (low value) crops and men for cash (high value) crops. If a 'woman's crop" is added value to it, it may become a "man's crop". When French beans became more lucrative in Kenya, men usurped either the land allocated for or income derived from production. Research shows that when women have better access to and control over resources, they have a greater increase in productivity than men. Women have also been known to invest more in productive activities than men.

Knowledge systems and access to networks

Women and men participate differently in formal and informal community based organizations, and use different networks for exchange of seeds for agrobiodiversity. In Nepal for example, traditional varieties are brought into an area by the bride upon marriage. Women exchange mainly with women, and men exchange mainly with men.

As a result of formal schooling and migration, indigenous knowledge among men declined in Kenya, while women retained a high and widely shared level of knowledge and even acquired men's knowledge as roles and duties changed. However, the knowledge of the older generation often is no longer passed on to the younger generations.

Both men and women farmers play an important role as decision makers in agrobiodiversity management. They decide when to plant, harvest and process their crops. They decide how much of each crop variety to plant each year, how much seed to save from their own production and what to buy or exchange. All these decisions affect the total amount of genetic diversity that is conserved and used.

In most farming systems, there is division of labour that determines the tasks that men and women undertake. In general, women have an important role in the production, processing, preservation and sale of staple crops. Men mainly focus on market oriented cash crop production. Weeding is mainly a women's task while spraying or fertilizer application is a man's job. Women and children often look after the smaller livestock species (goats, sheep, chickens) while men are often in-charge of cattle.

4.5 Gender and Agrobiodiversity Management

Women generally have the primary responsibility of providing their families with food, water, fuel, medicines and fibres, fodder and other products**.** Agrobiodiversity management is community based and requires the support of the whole community. Women play a very invisible role in the public affairs of many communities. This means that special effort needs to be taken to incorporate women in the management of agrobiodiversity. This may enhance the success of agrobiodiversity activities in the rural areas. It is worth noting that even mainstream agricultural policies and programmes tend to see farmers as men, or simply do not make a difference between men and women farmers. There is increasing concern that the vital contribution of women to the management of agrobiodiversity has been ignored or underestimated.

However, it should be appreciated that men and women perform different roles which are complementary in the management and sustainable use of agrobiodiversity. Women tend to be more actively involved in the household economy where there is use of a wider diversity of species for food and medicine than men. Men are more involved in traded goods which have lesser variety of species. It is evident that direct use values (food, fodder, shelter and medicine) are of more immediate importance to agrobiodiversity management, and it is in this sector that women are more involved. It is logical that for agrobiodiversity to be sustained, the people who manage it should be able to obtain benefits for doing so. Though both men and women benefit from direct-use values, men more often focus on income values through commercialization while non-income values are more important to women.

4.6 Key Points

- Recognition of the gender roles of men and women in agrobiodiversity conservation
- Participation of women as partners, decision makers and beneficiaries in agrobiodiversity management
- Identification of factors that may limit full participation of women in agrobiodiversity conservation and management

Exercise

From the case study:

1. Identify the agrobiodiversity issues being observed in relation to gender and age.
2. Why are women in traditional vegetable growing and young men in exotic vegetables?
3. Based on the information given, if you were to be posted to Bondo as an extension officer, what challenges would you face related to agro biodiversity?

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Module 5: Agrobiodiversity and Ecosystem Management

Samuel M. Mwonga

5.0 Learning Objectives

At the end of the module, the trainees should be able to:

i. evaluate the role of agrobiodiversity in an ecosystem
ii. identify ecological, social and economic constraints to sustainable ecosystem management
iii. demonstrate the role of agro-biodiversity in ecosystem management
iv. describe the concept of ecosystem approach in agrobiodiversity management

5.1 What is an Ecosystem?

An ecosystem is an ecological unit composed of living component (that is organisms) and non-living (environmental) component. It is a dynamic complex of plant, animal and micro-organism communities and their non-living environment acting as a functional unit. The living component, consisting of organisms, is described by both its genotype (dictated by its genetic attributes) and phenotype (manifested as morphological, physiological and behavioural attributes). The living and the non-living components of the ecosystem interact over time to produce a stable system. Such a system is depicted in the Ecosystem Model presented in Figure 5.1 below showing the interdependence of the biotic and the abiotic component and the relationship with adjacent ecosystems. The stability of the ecosystem is thus a function of not only the relationships within the unit but also with adjacent ecosystems.

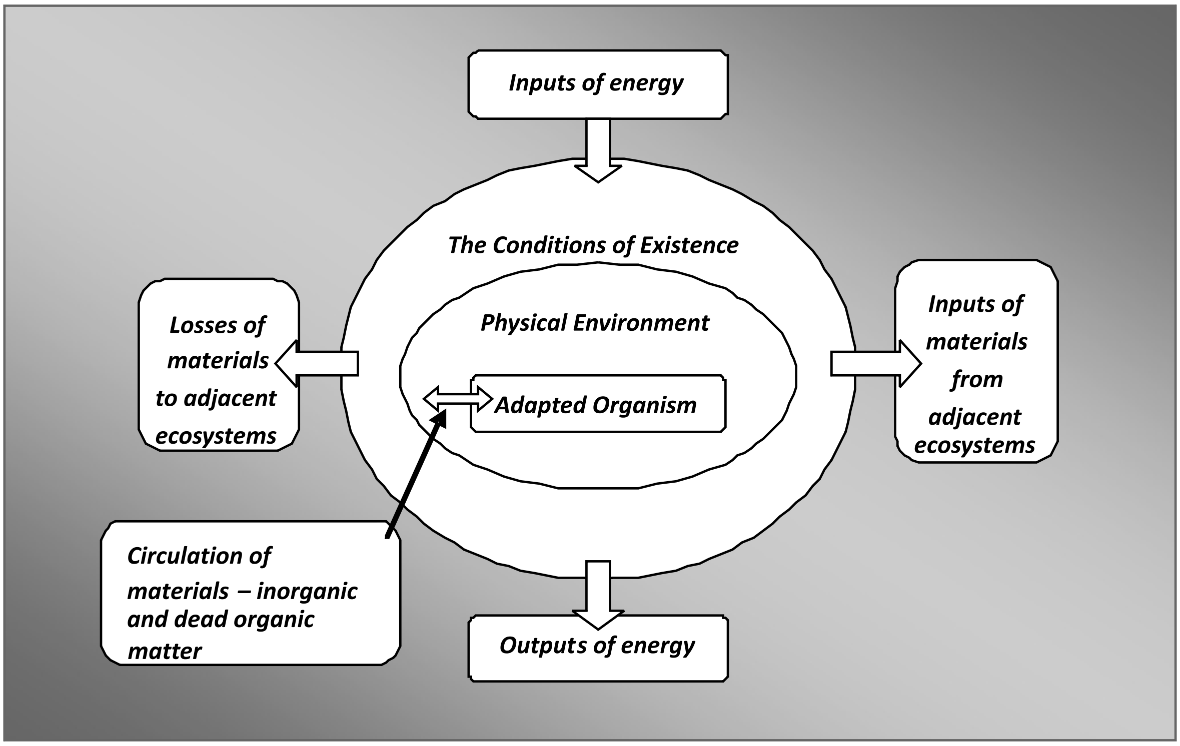

Figure 5.1: Ecosystem model (*Adapted from White et al., 1998***)**

Attributes of an Ecosystem

An ecosystem can be further understood by looking at the attributes that define it including the interactions between the various components within the ecosystem unit; these interactions include:

(a) Biomass and living space (habitat)

The habitat has both abiotic and biotic components. The interactions between the components within the habitat are described as "functional relationships". They include competition for resources, herbivory and predation.

(b) Pattern of species population

This is described as the spatial organization of the species. Spatial organization of animals are more fluid than plants, and change throughout the day or the year depending on food availability and quality, weather and particular activities that the organisms are engaged in. For example, populations change resulting from the seasonal migration of the wildebeest in the Kenyan Savannah in response to scarcity of food and water resources.

(c) Degree of presence for each species

This is measure of the actual contribution of a species to the community, for example, the amount of biomass of acacia vegetation in a savannah grassland community.

Habitats and Functional Relationships

Relationships of organisms not only partition for sharing of space, but the available energy and resources that sustain life. Functional relationships facilitate the transfer of energy and matter both between the abiotic and biotic component. The functional structure can be divided into the trophic organization of producer, consumer and decomposer levels.

The relationships of species in an ecosystem, the ecological niche of an organism, can be expressed by simple statement thus: *"**where it lives, what it does and how it is constrained by other organisms"*** **(**White et al. 1998)**.** The concept of ecological niche and species diversity are closely linked; as the species in a community increases the niche space is divided between more and more organisms. The concept of ecosystem stability is therefore complex and delicate as increases in species diversity can themselves create new and unexploited niche space.

5.2. Agro ecosystems and Agrobiodiversity

Agro-ecosystems are ecosystems that are used for agriculture. Agro-ecosystems may be identified at different levels or scales, for instance, a field/crop/herd/pond, a farming system, a land-use system or a watershed. There are virtually no ecosystems in the world that are "natural" in the sense of having escaped human influence. Most ecosystems have been to some extent modified or cultivated by humans for the production of food and income, and for livelihood security. The main dimensions of agricultural biodiversity include plant genetic resources, animal genetic resources, and microbial and fungal genetic resources. It is characterized by three sets of factors:

- the genetic resources (the biodiversity of plants and animals species),
- the physical environment (the abiotic component which contributes organic and inorganic materials (nutrients) into the ecosystem unit), and

- the human management practices.

Agricultural ecosystems are thus diverse and encompass the variety and variability of animals, plants and micro-organisms that are necessary to sustain key functions of the agro-ecosystem in food production and food security (FAO, 1999).

Box 5.1: Examples of Genetic Resources

1. Harvested crop varieties, livestock breeds, fish species and non-domesticated ('wild') resources within field, forest, rangeland and in aquatic ecosystems;
2. Non-harvested species within production ecosystems that support food provision, including soil micro-biota, pollinators and so on; and
3. Non-harvested species in the wider environment that support food production ecosystems (Agricultural, pastoral, forest and aquatic ecosystems).

There are several distinctive features of agrobiodiversity, compared to other components of biodiversity:

- Agrobiodiversity is actively managed by male and female farmers;
- many components of agrobiodiversity would not survive without this human interference; local knowledge and culture are integral parts of agrobiodiversity management;
- 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;
- as regards crop diversity, diversity within species is at least as important as diversity between species;
- because of the degree of human management, conservation of agrobiodiversity in production systems is inherently linked to sustainable use - preservation through establishing protected areas is less relevant; and
- in industrial-type agricultural systems, much crop diversity is now held *ex situ* in gene banks or breeders' materials rather than on-farm.

5.3 Agrobiodiversity and Ecosystem Function

The importance of agrobiodiversity encompasses socio-cultural, economic and environmental elements. About one third of the world's land area is used for food production; this means that agriculture is an important determinant of biodiversity. Biodiversity provides not only food and income but also raw materials for clothing, shelter, medicines, breeding new varieties; it performs other services such as maintenance of soil fertility and biota, and soil and water conservation, all of which are essential to human survival. All domesticated crops and animals result from human management of biological diversity, which is constantly responding to new challenges to maintain and increase productivity.

Valuable ecological processes that result from the interactions between species and between species and the environment include, *inter alia*, biochemical recycling, the maintenance of soil fertility and water quality, and climate regulation (e.g. micro-climates caused by different types and density of vegetation).

Some of the key functions for maintaining stable, robust, productive and sustainable agro-ecosystems are presented in Box 5.2 below:

Box 5.2: Functions of Agro ecosystems

1. breakdown of organic matter and recycling of nutrients to maintain soil fertility and sustain plant and consequently animal growth;
2. breakdown of pollutants and maintenance of a clean and healthy atmosphere;
3. moderation of climatic effects such as maintaining rainfall patterns and modulation of the water cycle and the absorption of solar energy by the land and its subsequent release;
4. maintenance and stability of productive vegetative, fish and animal populations and the limitation of invasion by harmful or less useful species;
5. protection and conservation of soil and water resources, for example through a vegetative cover and appropriate management practices, and the consequent maintenance of the integrity of landscapes and habitats;
6. sequestration of CO_2 by plants.

Source: FAO (1999)

Why biodiversity in Agro ecosystems is essential

The characteristics of biodiversity that are particularly relevant to the stability of agro ecosystems are listed in Box 5.3 below.

Box 5.3: Agrobiodiversity in Agro ecosystems

- Greater biodiversity leads, on average, to greater productivity.
- Greater biodiversity leads, on average, to lower year to year variability in productivity (that is, to greater stability).
- Greater biodiversity generally increases the quantity, quality, reliability and duration of pollination
- Greater biodiversity generally increases the resistance of production systems to invasion by pests and disease.
- Greater soil biodiversity generally increases plant resource use efficiency, including water, nutrients, and energy.
- Greater soil biodiversity generally increases soil quality.

Source: FAO (1999)

5.4 Agricultural production and agrobiodiversity

As discussed above, agrobiodiversity is a vital sub-set of biodiversity. It is a creation of humankind whose food and livelihood security depend on the sustained management of the diverse biological resources that are important for food and agriculture. Consequently, all domesticated crops and animals arise from human management of biological diversity.

Nearly one third of the world's land area is used for food production, making agriculture the largest single cause of habitat conversion on a global basis. In recent years, rising demand for agricultural production (food and industrial crop), combined with overgrazing, and urban and industrial growth, has resulted in agricultural expansion into forests and marginal lands. This overstretched use of land resources have led to considerable reductions in the levels of biological diversity in agricultural lands. In addition, changing consumption patterns have stimulated the evolution of agriculture from traditional to modern intensive systems. This threatens the traditional diverse food production system and results to loss in agricultural biodiversity including the loss of both harvested and unharvested species, varieties and breeds. The functional relationships within agro ecosystems are presented in the Figure 5.2 below. The Associated diversity is a result of the interaction between farm management and the landscape context of the farm.

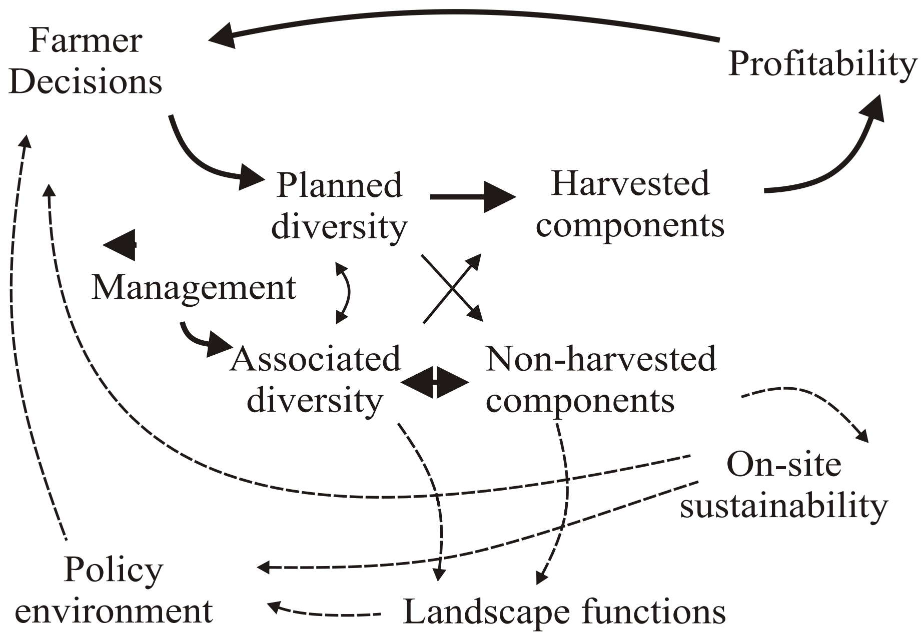

Figure 5. 2: A conceptual scheme depicting the complexity of relationships within an ecosystem

5.5. Agro ecosystems Management

Agriculture faces major challenges in increasing productivity and food security while protecting and enhancing environmental quality and conserving natural resources for future generations. The loss of biodiversity associated with agricultural production posses a great challenge in the sustainable management of agro ecosystems.

Management decisions about farming systems have an impact on the components of biodiversity. The mix of agricultural biodiversity in any one agro ecosystem is determined by a set of human-controlled factors and the underlying natural conditions. These include:

1. Underlying agro-ecological conditions (arid, semi-arid, humid)
2. Farmer's skills in on-farm agricultural biodiversity management
3. Farmer access to useful agricultural biodiversity (population pressure, local knowledge, and contacts)
4. Farmer access to other capitals that can substitute for natural capital (new technologies, agrochemicals)

It is through the manipulation of these factors that farmers can derive goods and services that contribute to sustainable livelihoods while improving the productivity of the production systems andmaintaining the ecosystem health. However, farmers face serious limitations in instituting practice that maintain or improve the genetic base in their production system.

Limitations of Agricultural Biodiversity in Production Systems

In order to device effective means of using agricultural biodiversity to improve agricultural production systems, it is imperative to appreciate the factors that limit better utilization of biodiversity assets (Box 5.4).

Box 5.4: Limitations of agrobiodiversity in production systems

- Demographic pressure - expansion of farming to marginal lands reduces diversity and leads to land degradation
- Agro ecological conditions for example, rainfall variability between and within years; this has a new dimension when considered with the unpredictability of weather patterns related to the ensuing global climate change.
- Inequality of access to biological resources
- Modern industrial agricultural production systems homogenization of breeds and crop varieties leading to erosion of biodiversity.
- Policies that promote intensive use of agrochemicals - pesticides, herbicides, fertilizers, feed supplements indirectly harm beneficial soil organisms

Genetic Resource Management

Managing genetic resources on farms concerns the entire ecosystem, including cultivated crops, forages and agroforestry species, as well as their wild and weedy relatives that may be growing in nearby areas. The guiding principles on effective on-farm genetic resources management programmes are presented in the box below.

Box 5.4: On-farm genetic resource management

1. Conserving at all three levels of biodiversity: ecosystem, species and genetic (intra-specific) diversity and the evolutionary processes and environmental pressures that affect genetic diversity.
2. *In situ* management of genetic resources involving conserving and using existing germplasm, and creating conducive conditions that allow for the development of new germplasm.
3. Integrating farmers into a National Plant Genetic Resources System through partnerships and establishment of equitable benefit-sharing between farmers.
4. Increasing farmer access to gene bank and farmer to farmer information exchange.
5. Maintaining or increasing farmers control and access over genetic resources through on-farm genetic resource conservation and the traditional knowledge links.
6. Managing stress and change through a diverse genetic resources base through the establishment of strong formal and informal seed systems.

Ecosystem Approach to Agrobiodiversity Management

According to the CBD the underlying causes of loss of agricultural biodiversity and the corresponding consequences of such loss for the functioning of agricultural ecosystems are not fully understood; in addition there are no widely accepted indicators of agricultural biodiversity (CBD).

To effectively manage agro ecosystems, two issues need to be addressed:

1. An integrated assessment of agricultural biodiversity as a whole rather than of its various components.
2. The development indicators and assessment methodologies to facilitate the identification of biodiversity friendly agricultural practices.

The Ecosystem Approach is a strategy for the integrated management of land, water, and living resources that promote conservation and sustainable use of resources including agrobiodiversity, in an equitable way.

The approach is based on the application of appropriate scientific methodologies focused on the levels of biological organization including the essential processes, functions, and interactions among the organisms (including humans) and their environments. It recognizes that humans, with their cultural, political and social diversity are integral components of ecosystems. The Ecosystem Approach can help to achieve integration of the three goals of sustainability:

- **sustainable** use of natural resources
- **equitable** sharing of the benefits derived from their use
- **conservation** of natural resources, based on fully functioning ecosystems

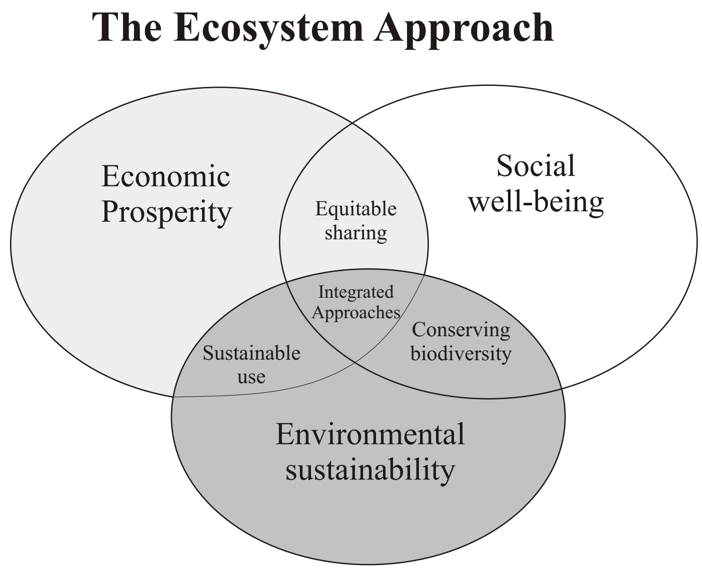

Figure 5.3: Conceptual diagram of the Ecosystem Approach
(Source: www.liv.ac.uk/science_eng_images/swimmer/diag...)

In Figure 5.3 above, the ecosystem approach is represented by the intersection of the three circles. It aims at balancing the conservation of biodiversity, sustainable use of its components, and a fair and equitable sharing of the benefits accruing from the utilization of genetic resources. It also requires the use of adaptive management practices that can deal with uncertainties.

The ecosystem approach does not preclude other management and conservation approaches, such as biosphere reserves, protected areas, and single-species conservation programmes. It could be viewed as an approach that integrates all these approaches and other methodologies to deal with complex situations. There is no single way to implement the ecosystem approach, as it depends on local, provincial, national, regional or global conditions. The section below describes a framework for applying the ecosystem approach as proposed by The Convention on Biodiversity.

The Ecosystem Approach Framework

The Convention on Biodiversity (CBD) has 12 guiding principles to the ecosystem approach. The first task in the Ecosystem Approach is to identify the problem or problems that need to be addressed. Complex problems may need to be broken down into several problems that can be addressed more easily. For example, to conserve a wetland ecosystem while facilitating its unsustainable use, it may be necessary to address:

(a) Ecological degradation resulting from unsustainable use of wetland resources.
(b) Community well being such as health, education, food security, and cultural values.

The other tasks involve the creation of a work plan followed by an implementation process. Each of these steps have issues that need to be observed in the implementation process. The guiding principles in the implementation of the approach encompass, among others, the following:

- Participation in decision making
- Decentralization of management to the lowest appropriate level
- Consideration of management effects on other ecosystems

- Management of ecosystem in an economic context
- Conservation of ecosystem structure and functioning
- Management of the ecosystem at appropriate spatial and temporal scales
- Institution of long term ecosystem management objectives
- A balance between conservation and use

The processes in the approach are summarized in Figure 5.4 below.

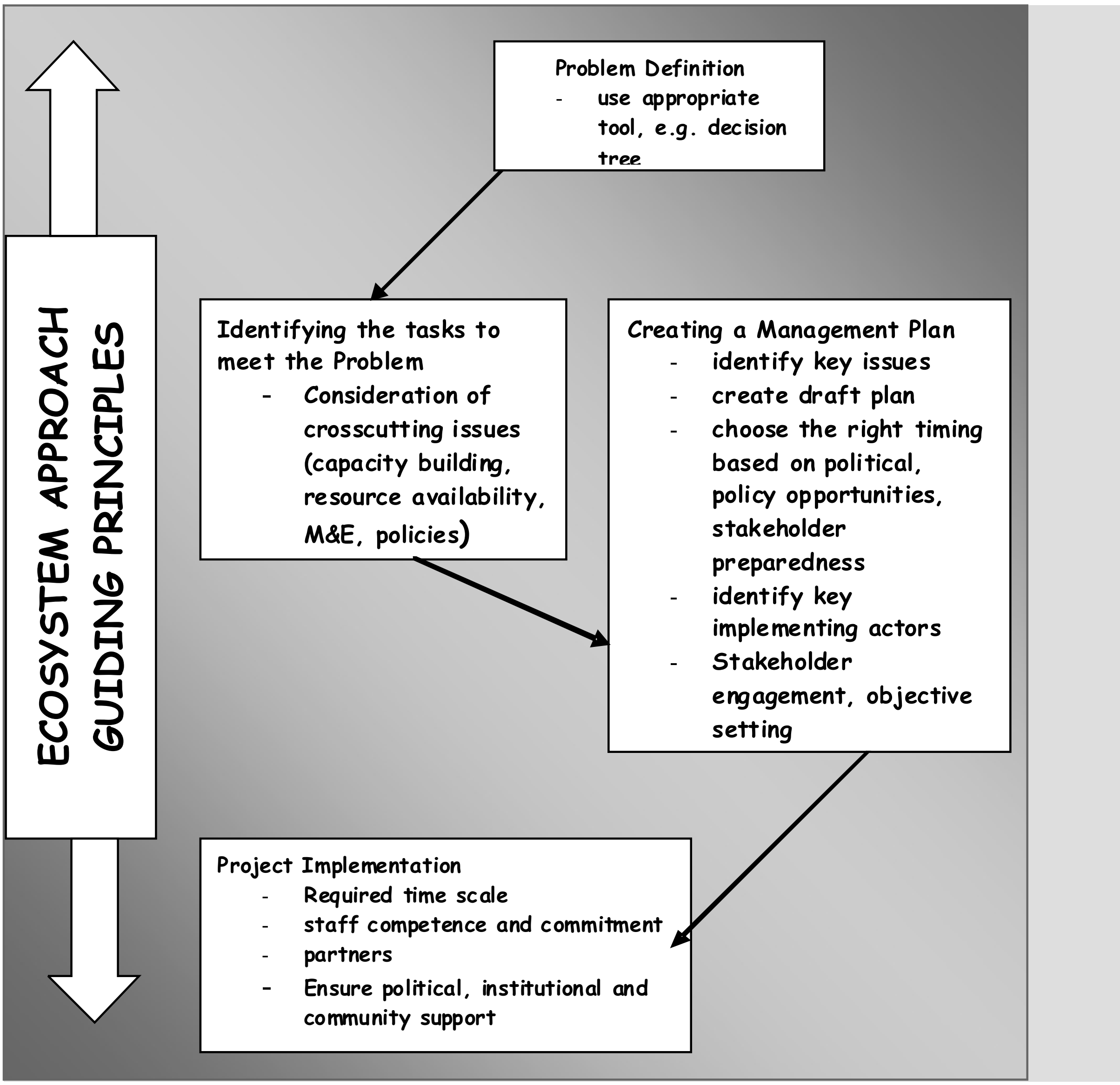

Figure 5.4. The Ecosystem Approach process

Functional Agrobiodiversity

A new concept in agrobiodiversity management referred to as Functional Agrobiodiversity (FAB) is being promoted in European agriculture. Functional Agrobiodiversity (FAB) is defined as ***"those elements of biodiversity on the scale of agricultural fields or landscapes, which provide ecosystem services that support sustainable agricultural production and can also deliver benefits to the regional and global environment and the public at large"*** (ELN-FAB, 2009). Functional Agrobiodiversity uses science-based strategies to optimize regulating, provisioning and cultural ecosystem services.

5.6: Key points

- An ecosystem is a dynamic complex consisting of plant, animal and micro-organisms all interacting in a non-living environment acting as a functional unit.
- Agrobiodiversity maintains the key functions in an ecosystem that support food production and food security.
- Agricultural diversity in any one ecosystem is determined by a set of human-controlled factors that influence management decisions within the context the underlying ecological and socio-economic realities.
- Biodiversity and agricultural production need not necessarily be in conflict with each other.
- For informed and beneficial use of agrobiodiversity for agricultural production and environmental quality, there is need to develop and share knowledge and practical experiences among the relevant stakeholders.
- The Ecosystem Approach is a strategy for the integrated management of land, water, and living resources that promote conservation and sustainable use of resources including agrobiodiversity, in an equitable way.
- The ecosystem approach does not preclude other management and conservation approaches integrates these approaches and other methodologies to deal with complex Situations.
- The Ecosystem approach is an integrative approach (not sectoral) that is applicable over different scales and is a methodological framework for management of complex systems.

5.7. Case Studies

Case study 1

Impact of species introduction on agrobiodiversity
(To use an appropriate case study in summarized form)

Plenary discussion of the Case Study 1
- Present and validate the key issues raised by the case study
- Share individual experiences on the key issues raised by the case study
- Summarize the lessons learnt from the case study.

Exercises

Exercise 1:

1. Identify 5 major ecosystems and for each list their components
2. Identify and list the major species inhabiting the components identified
3. Discuss and comment on the diversity of the species in the listed ecosystems

Exercise 2

Draw a “rich picture” showing the comparison between the diversity of agro ecosystems with undisturbed ecosystems

Exercise 3

Greater agrobiodiversity can act as a buffer against fluctuations in agricultural productivity and thus contributes to food security. Discuss and list the major points.

Time: 15 minutes

Method; group work followed by plenary discussion

Materials: Flipcharts, marker pens

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Module 6: Sustainable Use and Conservation of Agrobiodiversity

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6.0 Learning Objectives

At the end of this module, the trainees will have better understanding of the:

i. Principles of, and approaches to sustainable use and conservation of agrobiodiversity (AGBD)
ii. Appropriate application of practices that promote sustainable use and conservation of AGBD for food security and rural development
iii. New developments, concepts and innovative approaches to promote the sustainable management of biodiversity in agricultural practices

6.1 Why Conserve Agrobiodiversity?

Biodiversity in agricultural systems is under pressure worldwide. From the onset of domestication of plants for human use, agrobiodiversity has played a key role in sustaining and strengthening food, nutrition, health and livelihood securities worldwide. The loss of plant and animal biodiversity and its declining use in modern agriculture has generated much concern about future vulnerability of agricultural production and related insect pests and disease risks, food security and environmental stability. The potential of agrobiodiversity for coping with climate change is not well appreciated; yet transient hunger due to droughts, floods, and other natural disasters can be overcome through an integrated strategy for conservation and sustainable and equitable use of agrobiodiversity (Biodiversity Secretariat, 2008). Following various international conventions, sustainable use, sustainability and conservation of agricultural biodiversity (Box 6.1) have become top of the international development agenda.

There is a diversity of African flora and fauna; similarly, their uses are diverse including as food and medicines. These plant and animal reservoirs are under threat and already being eroded due to neglect, insufficient knowledge and inadequate support to institutions and communities that conserve biodiversity. However, the general public is largely unaware that agro-ecosystem diversity is under threat of being permanently lost (Negri, 2005).

Box 6.1. International Concerns.

Agrobiodiversity is that part of biodiversity which, within the context of agricultural production, delivers food, contributes to people's livelihoods and conserves habitats. It is the fruit of thousands of years of observation, selection, exchange and breeding by the world's farmers. (GTZ, 2000; FAO, 2006).

Sustainability refers to how people living in a particular place manage resources in order to maintain themselves on a daily basis and ensure that they have what they need as they move from one annual cycle to the next and from one generation to another. Women are the focal point of these activities (Collins, 1991).

Sustainable use entails the introduction and application of methods and processes for the utilization of biodiversity to prevent its long-term decline, thereby maintaining its potential to meet current and future human needs and aspirations (IISD, 2006).

Despite their importance, traditional genetic resources are being displaced from many areas. This is partly due to neglect by the scientific community who favour recently introduced species and high yielding breeds and varieties. This trend is detrimental to the local people because:

- Reliance upon introduced food crops and animals result in diminished dietary diversity
- There is also the probability that all essential nutrients are diminished.

Conservation of plant genetic resources depends first and foremost on the indigenous communities. The scientific quest into knowledge of local communities, particularly indigenous ones, should specifically address the role of women in indigenous communities as local conservators of plant genetic resources, seed managers and keepers of local knowledge. AGBD systems now tend to be found more in developing countries, among indigenous communities and small scale farmers, and in extreme or marginal environments. Economic and social development often leads people to abandon their valuable assets, thus preventing AGBD from contributing to improving the health and livelihoods of disadvantaged populations.

6.2 Erosion and Loss of Agrobiodiversity

Agrobiodiversity is important to farming communities and richer in the developing countries, among indigenous communities and smallholder farmers, and in extreme or marginal environments, is rapidly disappearing. The erosion is attributable to the past neglect, insufficient knowledge and inadequate institutional support to communities that conserve and use the AGBD. Indigenous and local communities have been effectively using biological resources for centuries and, where they have been weakened, it is empowering them that will enable us to conserve and sustainably use natural resources (Tewolde, 2001; Tewolde, 2002).

Decline in traditional crop diversity /landraces is due to change in cropping patterns resulting from economic considerations, population growth and land fragmentation, out-migration, change in food habits, and social values. To conserve and protect plant-based genetic resources, we need to conserve/manage the socio-cultural organization of the local people. Conserving biodiversity strengthens cultural integrity and values (Nautiyal et al. 2008).

Genetic Erosion

Genetic erosion is the loss of genetic diversity, including the loss of individual genes, and the loss of particular combinations of genes such as those manifested in locally adapted landraces. Currently, the rapid rate of species loss is due to the alteration or conversion of natural habitats into agricultural production. The main cause of genetic erosion in crops, as reported around the world, is the replacement of local varieties or landraces by improved or exotic varieties and species. Gene erosion is cited as the major cause of genetic erosion in all regions except Africa.

As farmers' replace the traditional varieties with modern varieties, genetic erosion frequently occurs because the genes and gene complexes found in the diverse farmers' varieties are not contained *in toto* in the modern variety. In addition, the sheer number of varieties is often reduced when commercial varieties are introduced into traditional farming systems. The genetic erosion of agricultural biodiversity is also exacerbated by the loss of forest cover, coastal wetlands and other 'wild' uncultivated areas, and the destruction of the aquatic environment. This leads to losses of 'wild' relatives, important for the development of biodiversity, and losses of 'wild' foods essential for food provision, particularly in times of crisis.

The diversity of cultivated plants has declined by some 75% since the middle of the 19^{th} Century. Originally, several thousand crop plant species provided food and clothing, but today the number has dropped to about 150. With regard to livestock, a projected 35% of mammalian and 63% of the avian genetic resources of the world's 5400 domestic animal genetic resources that are now registered by FAO are now at risk of loss with 740 breeds already listed as extinct (GTZ, 2000).

Reliance on introduced crops and plants

Traditional crops and livestock are being displaced with the recently introduced species and high yielding varieties. The trend is detrimental to farming communities because reliance upon introduced food crops is associated with diminished dietary diversity and access to essential nutrients. Sustainable use and conservation of AGBD is a top development agenda internationally because there is a rapid loss of AGBD. Sustainable use entails preventing long-term decline, thereby maintaining the potential of AGBD to meet current and future human needs and aspirations (IISD, 2006). To conserve AGBD, we need to manage plant and animal genetic resources in such a manner that we are able to preserve or restore lost, damaged or neglected components of AGBD and maximize use efficiency. Farming systems that maintain and use AGBD have a strong potential for improving accessibility to foods rich in nutrient quality.

Ignoring adaptability

Unique adaptive traits of local livestock include trypanotolerance, tolerance to worms and other parasites, salt tolerance, the ability to cover long distances and the ability to slow down metabolism. Indigenous livestock are more adaptable for utilization of low input production systems than the high performance breeds. While crossbreds (indigenous X exotic) may have positive effects in high-input systems without shortages of fodder and water, they hardly fulfil the expectations in low-input systems. Many crossbreeding programmes have, therefore, not had the beneficial effects on the livelihoods of smallholders. For instance, India has had enormous rise in milk output attributable to buffaloes and not to the introduction of cross-bred cows. Adaptation of local breeds is very specific and attuned to certain types of local vegetations, diseases and parasites. Breeds may look outwardly the same and be adapted to the same kind of climatic regimes, but still differ in the way they are able to support themselves on local feed resources. This explains the strong link of breed distribution to the local preferences of the communities.

Dependence on outside inputs and imports

In contrast to improved stock, indigenous livestock can be managed independently of external feed and health inputs. Successful use of improved or crossbreds requires a certain level of inputs, from feeding (cereals and concentrate) to housing and health management. If such high inputs are not sustained, then the improved animals die, fail to produce, or become uneconomical. For instance, financial crisis in Cuba and Southeast Asia due to lack of foreign exchange to purchase cereal animal feed resulted in the collapse of intensive poultry and pig production. The collapse led to a search for indigenous animal breeds that could be kept on locally available feedstuffs. Another example is the Nguni cattle in South Africa which were perceived as unproductive and farmers were induced to accept modern breeding packages comprising of crossbreeding with exotics and modern animal health care (dips and other veterinary drugs). When the input supply broke down in the wake of the political changes in the early 1990s, the crossbred cows could no longer perform economically. By that time, white farmers who had realized the advantages of the disease-resistant Nguni cattle were the only ones who still maintained the breed. Now there are aid programmes to re-supply poor farmers with Nguni breeding stock.

Narrow focus on raising productivity

In Europe, the enormous rise in productivity of livestock has partly contributed to the current agricultural scenario where family farms are no longer viable and rural income opportunities disappear rapidly. Raising productivity lowers to some extent animal ability to cope with local stresses of heat load, disease incidences and feed seasonality, as is illustrated by the Orma Boran cattle. This cattle breed is owned by the Orma people in the Tana River district of Kenya, descendants of the Oromo who migrated there from the Boran area in Ethiopia. Their cattle had been exposed to the tsetse fly over the centuries. In trials, the Orma Boran cattle have shown greater resistant to tsetse fly transmitted diseases than the improved Kenya Boran breed, which was selected on the basis of body weight. Under higher tsetse challenge, the Orma Boran grows faster than the improved Kenya Boran.

Women demonstrate greater preference for traditional breeds to improved ones, because they require fewer inputs, are less prone to disease and, therefore, do not create any additional demands. Projects in Ecuador to propagate larger and improved guinea pigs from Peru for generating additional income met with very little interest and response, because women did not want to have another burden on top of their household workload and were not really interested in selling guinea pigs anyway. Other contributing factors are:

- acute poverty in rural areas,
- inequities in land ownership and wealth,
- high rural-urban migration,
- conversion of agricultural lands to other uses,

- altered patterns of consumption,
- climatic changes,
- civil strife, wars and resulting mass migration are further causes of the loss of genetic resources and associated knowledge,
- bushfires, droughts and human pressure on niches,
- introduction of improved agricultural techniques, which treat many traditional food crops (especially vegetables) as weeds,
- introduction of exotic species, preferred by farmers for urban markets has not helped to conserve the traditional species.

6.3 Approaches to Conservation of Agrobiodiversity

The economic stake in conservation

Conservation of biodiversity will only succeed if the local people develop a tangible economic stake in conservation to improve their economic status. Creating an economic stake in conservation by linking the primary conservers with the market reinforces conservation. Local, national and international markets for landraces may be developed to increase the value of genetic resources.

Appropriating value to genetic resources

Appropriating value to a species encourages its conservation in a social system for various reasons. Local people have been maintaining and cultivating the genetic resources primarily for their nutritional and medicinal values, and out of certain beliefs, faiths and religious rituals, apart from their economical values. Such practices are disappearing among the villagers due to their changing lifestyles. Their timely promotion at the local level could, however, help in conservation.

Promotion of in-situ/ on-farm conservation

This is maintaining populations in the habitats in which they occur; and farmers are key players. In contrast to *ex-situ* preservation, on-farm conservation of genetic resources through cultivation and use in farms offers the advantage of further development (for instance, through targeted selection) and, therefore, evolutionary adaptation. *In-situ* conservation (Box 6.2.) includes:

- habitat protection of wild populations,
- maintenance of native species and varieties in traditional agro-ecosystems, and
- relevant environmental education.

Box 6.2. ***In-situ* and *Ex-situ* Conservation*:***

In-situ conservation is "The conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties" (UN Convention on Biological Diversity). *In-situ* conservation of cultivated species is primarily concerned with the maintenance of traditional crop varieties (or landraces) in the fields and home gardens of local subsistence farmers (i.e., "on-farm conservation"). Active participation by farmers and other users of genetic resources is essential for *in-situ* conservation of cultivated species.

Ex-situ conservation and promotion of agrobiodiversity, including:-

- establishment of living collections and germplasm banks,
- introduction of species and varieties into agro-ecosystems for agricultural practice.

Conservation through promotion

This entails identifying the constraints or factors responsible for decline, limited use or confinement to restricted locales of traditional crop species and animal breeds. These factors can be biological, cultural or production/use. Biological factors include improving our knowledge of these species, most of which are often poorly known scientifically though much information about them is often known to the local people in the communities where they grow and are utilized. An effective conservation strategy will build on this indigenous knowledge.

Network production

This aims at improvement of information exchange among all partners in the development of traditional crops production. Knowledge about different species has been restricted to small rural communities, and with the increasing migration into cities, towns and urban centres, the preservation of this knowledge is in danger. The starting point has been local knowledge about species which are locally preferred. Knowledge collection and seed production programmes either by women's groups or as community-based effort. An important way of securing the conservation of traditional vegetables is their utilisation.

Production/ use will require research and documentation of several aspects of the production and use systems of traditional crops in order to overcome constraints to their increased use and assess their conservation status. For wild and semi-wild species, an important possibility is to consider whether domestication could be a viable option. Post-harvest techniques need to be conserved, improved (Box 6.3.) and diffused to aid in the consumption of these species.

Box. 6.3. Value Addition

Strategies must aim at adding value to genetic resources to increase the sustainable utilization of these resources (through, e.g., characterization, domestication, participatory breeding, quality enhancement, product development and labeling, and increase income for farmers (GTZ, 2001)..

Conservation in sacred places and places of worship

Places such as churches and mosques, graveyards and monasteries and other protected areas have been important sites for protection of the indigenous flora (for non-cultivated species). In these areas, the wild flora and fauna have been afforded a degree of statutory protection, and could be used to specifically safeguard wild species used as food by local people. These areas include:

- state forests,
- community forests like Kaya forests and grazing lands, and
- national parks and reserves.

Cultural factors include understanding gender and human cultural diversity, which are essential for understanding the uses of plant diversity at species and genetic level (Box 6.4). Cultural changes associated with development may associate introduced foods with higher status and modernity at the expense of the better adapted, less costly and, in many cases, more nutritious local foods. Cultural programs that increase people's awareness of the benefits and value of traditional foods are also components of conservation.

Box 6.4. Gender Roles

Men and women hold different sets of knowledge through their different activities and resource management practices men and women have developed different expertise and knowledge regarding the local environment, plant and animal species, and their products and uses. These gender differentiated local knowledge systems play a decisive role in the *in-situ* conservation, management and improvement of genetic resources for food and agriculture because the decision to conserve depends on the know-how and perception of what is most useful to the household and local community (FAO, 1998).

6.4 Incentives for Community-Based Conservation through Utilization

Economic incentives

The most promising option for maintaining domestic animal diversity is to support, and provide incentives for local communities to continue herding and husbanding their AnGRs in their respective ecological contexts, but with the opportunity to develop by responding to or taking advantage of changing marketing and macro-economic situations. Such an approach suggests a win-win situation where conservation of domestic animal diversity can move simultaneously with the creation or maintenance of rural income opportunities. For such a strategy to succeed, a number of micro level and macro level conditions have to be met.

Globalization and market integration within the countries are threats to both biodiversity and local conservation from external economic agents. Conservation needs to be promoted through the means of economic incentives. An incentive for conservation is any inducement which is specifically intended to incite or motivate local people to conserve biodiversity. Consequently, pragmatic partnership should be developed to balance commercial interests and conservation ethics, and ensure a sustainable genetic resource base to achieve food security.

Genetic enhancement

Hundreds of landraces exist throughout Africa, an indication of their cultivation over a very long period. Their occurrence in often rather different agro-ecological zones has led to a great diversity and offers great scope for a plant breeder. The steps towards genetic enhancement are:

1. Collection of germplasm extensive collections of germplasm, especially from isolated areas and from people's home gardens.
2. Screening of germplasm to identify desirable characteristics. Non-selected material should be preserved in gene banks for later use. They may be of value when searching for tolerance/ resistance to stress factors.
3. Seed multiplication from a number of varieties, allowing farmers to choose those which suit them most.
4. Development of new varieties combining desirable characteristics or elimination of less desirable ones.
5. Agronomic research to identify major technical constraints facing farmers of traditional crops and carrying out research to overcome these constraints. Technical package development of appropriate technical advisory packages.

Recognition of local breeds and related indigenous knowledge

Special breeds need to attain official recognition as national assets. Interdisciplinary research, validating indigenous knowledge through systematic documentation of the breeding practices and strategies of particular communities as well as the particular traits of their breeds should be encouraged. Surveys of local breeding concepts and existing breeding institutions (such as community bulls) should be a standard component of all rural development practices.

Secure land rights for pastoralists

Without a sufficient pasture base, pastoralists and landless livestock keepers will not be in a position to maintain indigenous AnGRs. Guaranteed access to grazing pastures is an absolute prerequisite for conservation.

Pastoral breeds are global benefits

Because the wild ancestors of most domesticated animals are either extinct or on the verge of extinction, animals kept under the harsh conditions of pastoral systems are the main reservoir for genetic traits relating to disease and drought resistance, vitality and good reproductive capacity. Pastoral breeds represent global benefits and their loss can be considered in global terms, comparable to tropical rain forests. A strong argument can be made for entitling countries with pastoral populations, which are usually least-developed countries, to receive incentives from the world community to maintain these global benefits.

Enhancing the attraction of livestock keeping

Herding animals often carries the stigma of being a backward profession. Making livestock keeping a more attractive proposition for youths from pastoral/ rural backgrounds by providing training that builds on traditional knowledge, concepts and values, but also includes appropriate modern technologies is an avenue that is worth exploring.

Breeding societies

Support for breeding societies is one important step in community-based conservation. Breeding societies can fulfil important functions, such as information dissemination, exchange of animals and lobbying for brand names. However, the moulding of such societies exclusively along established lines, where fixed breed characteristics (such as colour, size, shape of the tail and ears) become the focus of breeding and are imposed on the population, should be avoided. The selection criteria that are at work in traditional low-input production systems (hardiness, disease and drought resistance) must never be compromised at the expense of adherence to narrow phenotypic characteristics.

Creation of marketing opportunities

Creating a demand for the products of local livestock breeds represents one of the best incentives for their conservation. Some of the opportunities are:

a). Niche markets/specialty products: Consumer demand and willingness to pay for higher-quality products is a prerequisite for successful niche marketing, since the comparatively lower productivity of local breeds must be compensated for by extra income.

b). Regionally typical food products: A number of examples are found in Europe where demand for regionally typical food products has turned the conservation of local breeds into a commercially viable undertaking. In southwest France, the Centre for Conservation of a Regional Biological Inheritance in the Midi-Pyrenees pursues such a goal with respect to the Gascon Pig. The Aubrac cattle breed and its products are an important component of a programme to revitalize the rural economy in the Aubrac region of southern France. The traditional cheese made from the milk of Aubrac cattle breed that had almost been forgotten was revived and protected label of origin has been applied for. The brand names of many French cheeses are protected and they can be made using only milk from a particular breed. The meat of this breed is already marketed under a special protected label.

The Majorcan Black Pig is the only autochthonous pig breed from Majorca (Spain). After introduction of intensive production systems and foreign breeds in the 1960s, its population started to decline. In the 1980s, a group of 89 farmers formed a breeding association and started pushing for a special label for local sausage (Sobrasada) made exclusively from the meat of this breed. In 1994 the Spanish Government created aregistered trademark for this product.

The Sambucana sheep from the Stura Valley in northern Italy was on the verge of extinction in the 1980s as a result of crossbreeding with rams of the higher-yielding Biella breed. However, the crossbreds were not able to negotiate the steep terrain and cope with the cold climate, which led to the abandonment of pastures and overgrowth of old paths. A consortium was set up to save the breed. A special brand name for guaranteed Sambucana meat was set up by the Italian Meat Industry Board.

c) Need for market linkages: Repeating the European model in developing countries may have difficulties. The experience concerning the Vietnamese I-pig, which is the subject of a conservation programme, based on farmers' preference for the breed for its better meat quality, though consumers in nearby villages and towns preferred to buy the fatter, cheaper meat. Only in the capital and larger cities is it possible to find customers willing to pay a higher price for higher-quality meat, but marketing mechanisms to reach this clientele do not currently exist.

d) Opportunity for the organic food market: Because they are kept under natural conditions, indigenous breeds seem well suited to provide products for the market in organic foods. Integrated and Participatory Agriculture Research (IPAR), a Philippine NGO, is promoting organic poultry production using local breeds as an alternative form of livelihood for poor farmers. An NGO in Uttar Pradesh in India has launched a campaign that advertises the milk of transhumant Van Gujjars buffalo pastoralists as "Natural" buffalo milk. In Kenya, we have vital milk in Nanyuki from camel milk. The branding set the buffalo and camel milk apart from the "synthetic" milk produced by farmers who feed their cattle with urea supplements and use drugs (oxytocin) to milk out their animals.

e) Export production: Although interest among and demand by consumers from the developed countries in products of indigenous AnGRs are conceivable, current import regulations and International Office of Epizootics (OIE) requirements are stacked against it. For instance, concerted efforts by Mauritania to export camel milk as a health food to the European Union market have so far been unsuccessful.

6.5. Practical Steps for Implementation of a Community-Based Conservation Programme

Community projects for the conservation of animal breeds can be conducted according to the same principles applied to other resources such as forest, pasture and crops. This will enhance contributions of local livestock breeds to sustainable rural livelihoods by doing the following:

i) Documentation/ appraisal, including through participatory appraisal of the advantages and disadvantages of the local breed; research into the factors that have led to its decline such as:
- lack of a market or access to it;
- lack of a resource base because of the encroachment of agriculture;
- legal restrictions, sometimes crossbreeding is enforced and use of indigenous bulls is prohibited;
- lack of income opportunities and interest by younger generations; and
- lack of competitiveness with improved breeds.

ii) Survey for indigenous breeding institutions, including community bulls, castration, ritual protection;
iii) Analysis of limiting factors and identification of a strategy for overcoming them;
iv) Setting of objectives in multi-stakeholder meetings and consultations to agree on respective commitments, financing plan, time frame, plan of action and M&E procedures;
v) Awareness generation in order to distribute the knowledge of the value and significance of the breed, rally the support of as many community members as possible and sensitize government organizations;
vi) Formation of an independent local institution/ organization with legal status to serve as a focus and executive agency for conservation activities. It should be composed largely of community Members. This will require mobilization and leadership development;
vii) Training and capacity-building in order to ensure that the new organization and the community will be able to pursue conservation after the end of the project and outside inputs;
viii) Overcoming constraints by securing of a resource base through negotiations, advocacy and facilitation; development of markets or marketing channels for specialty products, through a market survey, research on processing methods, product launch, building up of a distribution

network; and negotiation of subsidies from government or other sources;

ix) Impact assessment through participatory evaluation and exit of the project staff.

6.6. Developing the Genetic Resources of Communities

Promoting seed exchange and community seed banks

Traditional seed varieties are not readily available in the market. In such circumstances, farmers resort to exchanging seeds within the village or from neighbouring villages. Local seed exchange is, therefore, an important instrument for seed supply and diffusion. A strategy against the genetic erosion of Africa's most important genetic resources has been the conservation of crop genetic resources in national gene banks. The gene bank carries out the maintenance and management of collections of the major crops grown in a country; as well as conservation of useful wild species that are indigenous to the country.

Empower local communities with commercial benefits from the unique genetic attributes

The local breeds kept by communities may be endowed with genetic traits of interest to animal breeders in other areas (including the north) and, therefore, with commercial potential. These traits may not be immediately apparent or present in all individuals. Consequently, there is a need for systematic screening, preferably involving participatory methods building on indigenous knowledge. Aid to develop local breeds must be combined with efforts to empower local communities so that they will also receive commercial and other benefits from the unique genetic resources that they are nurturing. Some attempts made are listed below:

- `In the Highlands of Chiapas (Mexico), the extensive expertise of Tzotzil Indian shepherdesses in evaluating animals for fleece characteristics according to their indigenous knowledge is an important aspect of a genetic improvement programme for Chiapas sheep.
- In Bolivia, a systematic search for desirable characteristics found that the local Ayapaya llama kept by the Wallat'ani community in the highlands had better fibre quality than the lowland llama and this now forms the basis of breeding activities to develop the Ayapaya ecotype further for the benefit of the local community.
- Systematic evaluation of guinea pig strains revealed that local lines were better than exotic ones with respect to number of offspring born and weaned and total weight.

Pastoralists' rights and legal safeguards against biopiracy

The international debate on access to and benefit-sharing of genetic resources has so far focused exclusively on plants and less attention to local AnGRs, although it is not only different but also more pertinent. Animal breeders, and especially pastoralists, have much more of a “collective identity”, because a breed is the product of communal institutions. Many animal breeds are associated with particular indigenous communities or ethnic groups whose identity is linked to those breeds and who regard themselves very much as their proprietors or even guardians. Moreover, they have developed elaborate social mechanisms to share these resources equitably within the community while preventing or limiting the access of outsiders to them. Consequently, a much clearer case can be made for the “collective rights” of pastoralists than for traditional plant breeders.

Some of the animal genetic resources owned by indigenous communities have been recognized as being of great interest to livestock producers elsewhere. Their qualities/ genetic traits could vastly increase the efficiency even of industrialized animal production systems. One example is provided by the Red Maasai sheep, which is endowed with genetic resistance to internal parasites. This trait is of great interest to commercial sheep farmers in the North (particularly Australia and New Zealand, but also elsewhere); since helminths can no longer be combated with antihelminthic drugs (they have become immune to them). The prospect of the genetic sequence related to helminth resistance being identified by scientists raises the question of the ownership of this information and of the genes. The exact nature and scope of such benefits which could be grazing rights, animal health care or monetary benefits is an issue that warrants discussion involving all stakeholders. The implications of this issue for future global food security, the national interests of the countries involved and the livelihoods and right to self-determination of indigenous groups are enormous.

Table 6.1. Differences between crops and livestock in conservation strategies

Use and conservation strategy	Crops	Livestock
Breeding on-farm	More opportunities for farmers; they have more crops than livestock per farm	Limited opportunities for farmers; fewer animals than crops per farm
Change genetic diversity by farmers	Vegetative reproduction lowers genetic diversity Rapid change in diversity attainable from shorter generation interval	Sexual reproduction increases genetic diversity Slower change in diversity with longer generation interval
Threats to biodiversity	Greater all in agro-ecosystems	Greater in agro-ecosystems of industrialized states
Bio-piracy incidences	More frequent from smallholder AGBD	Less frequent in smallholder AGBD
Conservation strategies	Seed storage technology widely with smallholders gene banks by government	Semen/embryo storage technology is not with smallholders Animals in public zoos and farms Cryo-preservation deep freezing costly
Ownership frameworks for use and access	Benefit sharing mechanisms more elaborate	Benefit sharing mechanisms poorly developed

6.7. Differences between AnGRs and PGRs, and their Management

There are some intrinsic differences between plant and animal genetic resources that influence the way they can be used sustainably and conserved, which are summarised in Table 6.1. Animals reproduce sexually, whereas many plants can be reproduced vegetatively. This means that breeds of animals can be genetically more diverse than varieties or cultivars of plants. Within animal breeds, separate lines have to be differentiated. The storage and transport of seeds is an age old practice with simple means, whereas the storage of semen or embryos is technically demanding (i.e., needs liquid nitrogen) and is a practice that is much more recent and not widespread with smallholders. The rate of reproduction - with the exception of fish and insects - in animals is much lower than in plants. Also, the generation interval is longer in most animal species than in plants (except trees). This means that radical changes in genetic composition of an animal population take longer than in plants.

Generally, farm animal genetic diversity is much more threatened in industrialized than in developing countries. Plant genetic resources are rather equally threatened in both industrialized and developing countries. Certain activities necessary to maintain PGRs may, therefore, not have an equivalent in managing AnGRs. Ownership of animals generally includes ownership of its genetics. There are far fewer bio-piracy cases in animals than in plants. A farmer keeps fewer animals than he/ she grows plants and, therefore, the possibilities for breeding by one farmer are more limited in animals than in plants. Consequently, conservation strategies for farm animal and farm plant biodiversity differ in many circumstances. Whereas *ex-situ* conservation in gene banks is a useful tool for plants, it is not for animals. For animals, the current priorities are in documenting the present state of farm animal biodiversity and less in managing *ex-situ* conservation, and improving the legal framework regarding access and ownership.

Case Study 6.1: Development of Strategies for *In-Situ* Conservation of PGRs for Food and Agriculture in the Semi-arid Regions of Zimbabwe

Overall goal: improved food security for small-holder farmers through the conservation and sustainable utilization of PGRs for food and agriculture (PGRFA). The specific objectives were:

i) to understand the practices and systems for conservation and utilization of PGRFA on-farm;

ii) to develop strategies for, and implement *in-situ* and *ex-situ* conservation and utilization of PGRFA in Zimbabwe.

Aim: conserving AGBD through an understanding of traditional conservation methodologies obtained through preliminary and detailed surveys and an understanding of the existing biodiversity, obtained through germplasm collections, National Gene bank- and farmer-based morphological characterizations, molecular characterization and GIS studies; and implementation of AGBD conservation activities at the farmer level. Activities included seed fairs, farmer-field fora and the establishment of community-level seed banks. The project also focused on the conservation activities implemented at the farmer level, namely, the seed fairs, farmer-field fora and the community seed bank. The project encouraged AGBD conservation and introduced two improved varieties of Pearl Millet and an improved variety of cowpea. Some of the traditional varieties of sorghum were replaced by improved ones.

To increase awareness of AGBD, and to facilitate the exchange of germplasm, seed fairs were conducted in 3 consecutive years. Farmers were encouraged to display the diversity of crops and varieties that they grew with prizes presented according to three criteria; diversity, seed quality and presentation; which provided an incentive for farmers to collect and conserve biodiversity. Farmers expressed enthusiasm for the seed fairs as they provided a forum where farmers could meet, interact and exchange germplasm. This study found that a couple of interested farmers acquired a large number of varieties and crops, predominantly through exchange at the seed fairs, so that they could win first prize at the next seed fair. These two farmers seemed to have a genuine interest in the maintenance of varieties, even though it took an enormous amount of work to maintain them, and said they would continue in the maintenance even if the seed fairs stopped. The enthusiasm of these farmers, however, discouraged other farmers from conserving diversity as other farmers knew they would never get the good prizes. It was found that the numbers of farmers attending the seed fairs declined over the years mainly because farmers were discouraged from attending if they did not receive a prize.

At farmer-field fora, farmers were taught about the multiplication of varieties in isolation to maintain varietal integrity, row spacing, etc. This activity took place during farmer-based morphological characterization. It was difficult to really determine the impact of this activity on biodiversity conservation as there was another project running parallel to this one in which farmers were learning how to grow an improved Pearl-Millet Variety (PMV3) in isolation and under contract with a local seed company.

***Source*: Rusike and Ferguson (1997).**

Discuss the useful lessons that can be learnt from the case study.

6.8. Key Points

- For protection of biodiversity, we must understand the local knowledge systems and the role of indigenous communities. Conservation of plant genetic resources depends first and foremost on these communities.
- Men and women play important, but often distinctive roles, in the management and conservation of agrobiodiversity.
- Rural men and women in indigenous communities play an important role as local conservators of PGRs, seed managers. They are the managers of biodiversity and hold in-depth knowledge of local plants; they are, therefore, the custodians of PGRs.
- Women are traditional caretakers of crop genetic diversity in agriculture. They have a vital fund of experience in seed selection and "plant breeding."
- As farmers, rural women are responsible for growing and collecting food, and for deciding how to use diverse natural resources to daily household needs.
- Culture and cultural values are, and have been, the driving force of biodiversity Management and conservation. Changing food culture and dietary habits can lead to the erosion of plant diversity.

Exercises

Exercise 1: Promoting sustainable use and conservation of Indigenous livestock in Kenya

1. Name any indigenous breed of livestock you know of that:

i. Is currently threatened with extinction?

ii. Has become extinct?

iii. You would want urgently given a special programme of sustainable use and conservation.

2. Enumerate any three benefits to the global community from sustainable use and conservation of indigenous livestock breeds.

Time allocation: 15 minutes

Exercise II: Sustainable use and conservation of indigenous livestock in Kenya

Koriema goat meat, which was a popular roast goat meat in Baringo district, has rapidly lost the huge market share it enjoyed up to the mid 1990s. Presently, farmers are being encouraged to adopt imported high milking dairy goats and the productive Kenya Dual Purpose Goat (KDPG) breed.

a) Outline the reasons underlying the declining status of Koriema goat.

b) Outline the options through which Baringo farmers may enhance revival of sustainable use and conservation of the Koriema goat

Time allocation: 20 minutes

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Module 7: Agrobiodiversity and Soil Quality

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7.0 Learning Objectives

At the end of the course, the trainee is expected to have an understanding of:

i. How agrobiodiversity affects soil quality
ii. Soil biological diversity and nutrient cycling
iii. Role of cropping systems in agrobiodiversity
iv. Participatory soil quality assessment in agrobiodiversity

7.1 Agrobiodiversity Effects on Soil Quality

Plants, animals and microbes interact at various levels (species, varieties, breeds and management options) to sustain key (agro) ecosystem functions such as nutrient cycling and retention in soils. The functions carried out by different organisms within ecosystems collectively constitute functional diversity. More accurately, functional diversity is the variety, multiplicity or range of processes and their interactions performed by different species within an ecosystem. Functional diversity includes the many ecological interactions among species (e.g. competition, predation, parasitism, mutualism), as well as ecological processes such as nutrient cycling. Because functional diversity is less tangible and more difficult to measure, it is often ignored in discussions on biological diversity. However, the ecological processes represented by functional diversity provide the "ecological services" (i.e. biophysical functions and ecological processes that support human life and welfare) to support all organisms, including humans. Soil quality enhancement is an ecological service that agrobiodiversity contributes towards.

Ecosystem services

Humankind benefits from a multitude of resources and processes that are supplied by natural ecosystems. Collectively, these benefits are known as ecosystems services and include products like clean drinking water and processes like the decomposition of wastes. Ecosystem services are distinct from other ecosystem products and functions because there is human demand for these natural assets. Services can be subdivided into five categories: *provisioning* such as the production of food and water; *regulating*, such as the control of climate and disease, carbon sequestration; *supporting* such as nutrient cycles and crop pollination; *cultural*, such as spiritual and recreational benefits, and *preserving*, which include guarding against uncertainty through the maintenance of diversity (Daily 2000; MEA 2005).

Ecosystems and ecosystem services play a significant role in Kenya's economy and people's livelihoods: About 80 % of Kenyans derive their livelihoods from agricultural activities; agriculture contributes, directly and indirectly, about 53 percent to the economy; nature-based tourism, fishing, and timber production are other important sources of environmental income (WRI et al., 2007).

Soil quality

Soil is one of the most important natural resources. It is an integral component of terrestrial ecosystems, and an understanding of the soil system is crucial to the success and environmental harmony of any human use of the land. Practices such as clearing of forests for farming, manure and fertilizer application, leaving the land fallow,all influence the soil and the soil organisms and higher plants growing in or on the soil. Likewise, the way plant communities are managed influences the long-term stability and quality of the soils in which they grow. Soil quality is how well soil does what we want it to do "fitness for use" (**Pierce and Larson 1993)**. More specifically, soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation (Doran and Parkin, 1994). Soil organic matter and soil organisms play a major role in soil quality.

Soil has both inherent and dynamic qualities (Table 7.1). Inherent soil quality is a soil's natural ability to function. For example, sandy soil drains faster than clayey soil. Deep soil has more room for roots than soils with bedrock near the surface. These characteristics do not change easily. Dynamic soil quality is how soil changes depending on how it is managed. Management choices affect soil properties such as the amount of soil organic matter, soil structure, soil depth, water and nutrient holding capacity. Soils respond differently to management depending on the inherent properties of the soil and the surrounding landscape. Some properties such as soil texture, mineralogy, steepness of slope, and stoniness are inherent characteristics of the soil and are not subject to change through land and crop management. These properties, however, are important in determining the best management systems to be used. Other soil properties are easily influenced by management and they change immediately. For example, soil water content is affected by irrigation and rainfall, and nutrient element levels are affected by application of chemical fertilizers. Also, the compaction of the soil can result from passes across the field in one day by farm machinery. Intermediate between these two extremes are properties that are subject to change only through long-term management efforts (Table 7.1). Soil organic matter, microbial biomass and soil aggregation, are examples of intermediate indicators of soil quality.

Table 7.1: Classification of soil properties contributing to soil quality based on their permanence and sensitivity

Ephemeral	**Intermediate**	**Permanent**
(*Changes within days due to routine management)*	***(Subject to management over several years)***	***(Inherent to site or profile)***
Water content	**Aggregation**	**Soil depth**
Field respiration	**Microbial biomass**	**Slope**
PH	**Basal respiration**	**Climate**
Mineral N	**Specific respiration**	**Restrictive layers**
Available K	**quotient**	**Mineralogy**
Available P	**Active C**	**Texture**
Bulk density	**OM content**	**Stoniness**

Source: Brady and Weil, 2002

Importance of AGBD in maintaining soil quality

- AGBD ensures long-term agricultural productivity. Continuous cropping without replenishment causes decline in soil fertility. In addition, lack of appropriate soil conservation measures leads to soil degradation, through the loss of fertile topsoil. Practices such as crop rotations that include high residue plants, using optimal nutrient and water management practices to grow healthy plants with large amounts of roots and residue, growing cover crops, applying manure or compost, strip cropping, and mulching increase organic matter and hence soil quality.
- **Diverse cropping systems**

  Diversity is beneficial for several reasons. Each plant contributes a unique root structure and type of residue to the soil. A diversity of soil organisms can help control pest populations, and a diversity of cultural practices can reduce weed and disease pressures. Diversity across the landscape can be increased by using buffer strips, small fields, contour strip cropping or multiple cropping. Diversity over time can be increased by using long crop rotations. Changing vegetation across the landscape or over time not only increases plant diversity, but also the types of insects, microorganisms, and wildlife that live on the farm

7.2 Soil Biological Diversity and Nutrient Cycling

Most of the biodiversity of agricultural systems resides in soil. The biological diversity of soil includes the number of species contained within an ecosystem, genetic variability within each species and the functioning of those species within the ecosystem. Microbial diversity is critical to ecosystems functioning due to the diversity of processes for which microbes are responsible. In agro ecosystems, microbes play important role in nutrient cycling, residue decomposition, soil structure, and pest balance, functions that are critical to the productivity and sustainability of such systems. While the majority of soil microbes are beneficial to plant growth, potential harmful effects from soil microbes include plant diseases, production of plant-suppressive compounds and competition for water and nutrients.

Effects of disturbance on soil biological diversity

The aboveground plant community influences biological spatial heterogeneity in the soil, particularly in the rhizosphere (the volume of soil under the direct influence of the root) due to the variability in chemical composition of exudates. Soils with perennial crops have more diverse soil organisms such as nematodes than soils with annual crops. Root growth is more extensive and stable with perennial than with annual crops. Differences between soils with perennial and annual crops are greatest if the perennial crops have been established for at least three years. In fields where annual crops are grown, the diversity of soil organisms is increased by management practices that increase crop diversity such as crop rotation, polycultures, crop mixtures, trap crops and intercropping. Available analysis shows that among the bacterial among the bacterial-feeding nematodes Cephalobidae are often the most abundant group in soils; Rhabditidae may increase following a resource pulse; in stressed, natural environments Plectidae may be important (Yeates, 2003).

Reductions in aboveground plant diversity caused by disturbances such as tillage, overgrazing, and pollutants may decrease microbial diversity. Tillage, for example, damages soil fauna by abrasion, by closing soil cracks and pores, and by promoting drying of surface soil. Tillage also disrupts soil aggregates, releasing nutrients and organic matter that stimulate bacterial and fungal populations. Subsequently, populations of fungal- and bacterial-feeders increase. In addition, different types of tillage affect the abundance and diversity of soil organisms by interrupting successional sequences at different stages (Figure 7.1). Other management factors that impact negatively on soil animals include intensive use of pesticides, soil erosion and use of heavy machinery.

Agricultural management practices that increase soil fertility and the quantity and quality of soil organic matter increase populations of some soil organisms by increasing their food supply. Fertilization influences soil organisms positively or negatively depending on the quality of the fertilizer. High doses of mineral or manure fertilizers can harm meso fauna because of toxicity (e.g. anhydrous ammonia) or high osmotic pressure due to salt accumulation. Use of compost may help to avoid negative effects of manure on soil organisms. Application of aged compost can increase suppression of plant pathogens in soil by increasing the effectiveness of bio control agents.

Why it is important to include soil biological diversity in AGBD

Nutrient cycling

Soil organisms constitute a large dynamic source and sink of nutrients in all ecosystems and play a major role in plant litter decomposition and nutrient cycling. Microbes break down complex compounds in organic matter to simpler, smaller compounds. In agro ecosystems, crop residues and animal manures make the major sources of organic matter into the soil. The two main goals of organic matter management are to (1) provide nutrients for crops, and (2) restore or maintain soil organic matter and accruing benefits to other soil properties.

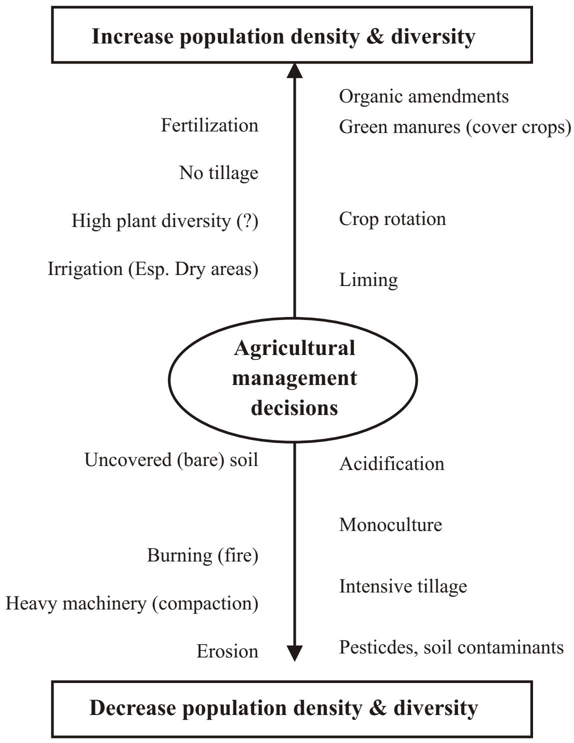

Figure 7.1. The effect of different agricultural management practices on soil animal populations. The position of the various practices on the y-axis represents their hypothetical relative importance to increasing or decreasing soil animal populations (Brown et al. 2007)

Plant-microbe symbiotic relationships

Mycorrhizal and rhizobia associations are important examples of plant-microbe relationships. Mycorrhizas are non-pathogenic fungi that form symbiotic associations with plant roots. Mycorrhizal associations have been shown to be of greatest importance in stressed environments, phosphorus deficient soils, eroded sites, and acidic or reclaimed lands. The fungal hyphal threads allow the roots to access nutrients and water that otherwise would be inaccessible to the plant, and may be of particular benefit to the phosphorus nutrition of the host plants. This relationship is particularly beneficial under moisture-limited conditions and may also protect plant roots from pathogens. Mycorrhizal associations are enhanced by crop rotation and management practices that favour minimum soil disturbance.

Next to plant photosynthesis, biological nitrogen fixation is probably the most important process for life on earth. Bacteria, of the genera *Rhizobium* and *Bradyrhizobium*, forms nodules on the roots of legumes and fixes atmospheric nitrogen into plant-available forms. Inoculation of legumes with nitrogen fixing bacteria can add appreciable amounts of nitrogen to the soil. Globally, legumes add 35 million tons (Mg) slightly under half of all nitrogenous fertilizer production of 77 Mg (Brady and Weil, 2002).

Soil aggregation

Soil organisms play a major role in the formation of soil structure. Fungi and actinomycetes produce hyphal threads that bind soil particles together. Extracellular polysaccharides (glues) produced by bacteria and fungi bind soil particles together, while humic materials from microbial action form organic matter/clay complexes. Earthworms and termites move soil particles around, often ingesting them and forming them into pellets or casts. Plant roots also move soil particles as they push their way through the soil. This movement forces soil particles to come into close contact with each other, encouraging aggregation. Soil aggregates reduce erosion and improve water infiltration and soil aeration. Soil stability may be managed by the addition of different amendments to stimulate microbial activity.

Biological control

Soil microbial diversity is a primary resource in the emerging area of biological control of plant pathogens. Biological control is the suppression of one pest by using its natural enemies (antagonists), and can be used to control insects, pathogens and weeds by either lowering the populations of the pest or by reducing the pest's impact. Bacteria and fungi that produce different types of antibiotics can be used to control many plant pathogens.

Deleterious rhizobacteria (bacteria adapted to living in the rhizosphere) that specifically inhibit various grass weeds, but do not affect the crop, have been isolated from soil (Li and Kremer, 2006) and shown to inhibit weed growth by the production of plant-suppressive compounds. These bacteria have excellent potential as biological control agents because they are aggressive colonizers of roots.

Economic value

Soil biodiversity has both direct and indirect economic values. As indicated earlier, recycling of organic wastes is one of the most important roles of soil organisms. In monetary terms, decomposition of organic materials contributes approximately US $ 760 billion, about 50% of the total benefits of soil biotic activity worldwide. Biological nitrogen fixation in natural and agricultural ecosystems contributes approximately 140 to 170 million tons of N, valued at about US $ 90 billion yr^{-1}. Other ecosystems services include bio-remediation of polluted soils and water (US $ 121 billion yr^{-1}), the control of pests (US $ 160 $ billion yr^{-1}), the usefulness of various wild insects, plant roots and mushrooms as food for human consumption (US $ 180 billion), and the pollination of plants (US $ 200 billion yr^{-1}) (Brussaard et al., 2007, Gardi and Jeffery 2009).

7.3 Cropping Systems and their Benefits to Agrobiodiversity

A cropping system may be defined as a community of plants which is managed by a farm unit to achieve various human goals. It comprises all cropping patterns grown on the farm and their interaction with farm resources, other household enterprises and the physical, biological, technological and sociological factors or environments. Table 7.2 shows different types of cropping systems.

Table 7.2. Common description of cropping systems

Cropping system	Definition
Monoculture	one crop grown on the same plot for successive years
Mono cropping	one crop grown on one plot in a single year
Multiple cropping	two or more crops grown on the same plot in one year, either simultaneously or sequentially
Sequential cropping	more than one crop a year on one plot in sequence
Double/triple cropping	two/three crops in sequence per plot per year
Intercropping	two or more crops grown simultaneously on one plot
Mixed intercropping	simultaneous cropping with random distribution
Row intercropping	two or more crops per plot sown singly in separate rows
Strip cropping	two or more crops per plot sown singly in separate strips
Relay intercropping	simultaneous cropping for only part of crop life cycles
Ratoon cropping	cultivation of crop regrowth after harvest

Source: Gosden and Hather, 1999

In most natural ecosystems, the greater the diversity, the more resistant an ecosystem is to change and the better able it is to recover from disturbance. In agricultural ecosystems, disturbance is much more frequent, regular and intense. Although it is more difficult to maintain diversity in agro ecosystems, introducing and managing diversity on the farm provides both ecological and economical benefits (Figure 7.2, Box 7.1). Mechanisms which are possibly responsible for these ecological benefits are related to the lower pest and pathogen incidence found in intercrops, for example, and to the higher resource use efficiency of crops with different root systems and leaf morphology. However, introduction of diversity on the farm must be well planned to ensure that the anticipated benefits are obtained. Accrued benefits may result when a unique or complementary effect is added to the agro ecosystem, e.g., by planting genotypes with specific genes for higher yield or pest resistance, using cover crops or intercropping or including a plant functional group, such as a legume, that increases nitrogen inputs and cycling. Current evidence suggests that merely adding more species to most agro ecosystems has little effect on function, given the redundancy in many groups, especially for some members of the soil biota e.g., organic matter decomposition or N-mineralization, that are carried out by a large variety of bacterial and fungal species (Jackson et al., 2007). However, as shown in Box 7.1, advantages of well-planned diverse agro ecosystems outweigh the disadvantages.

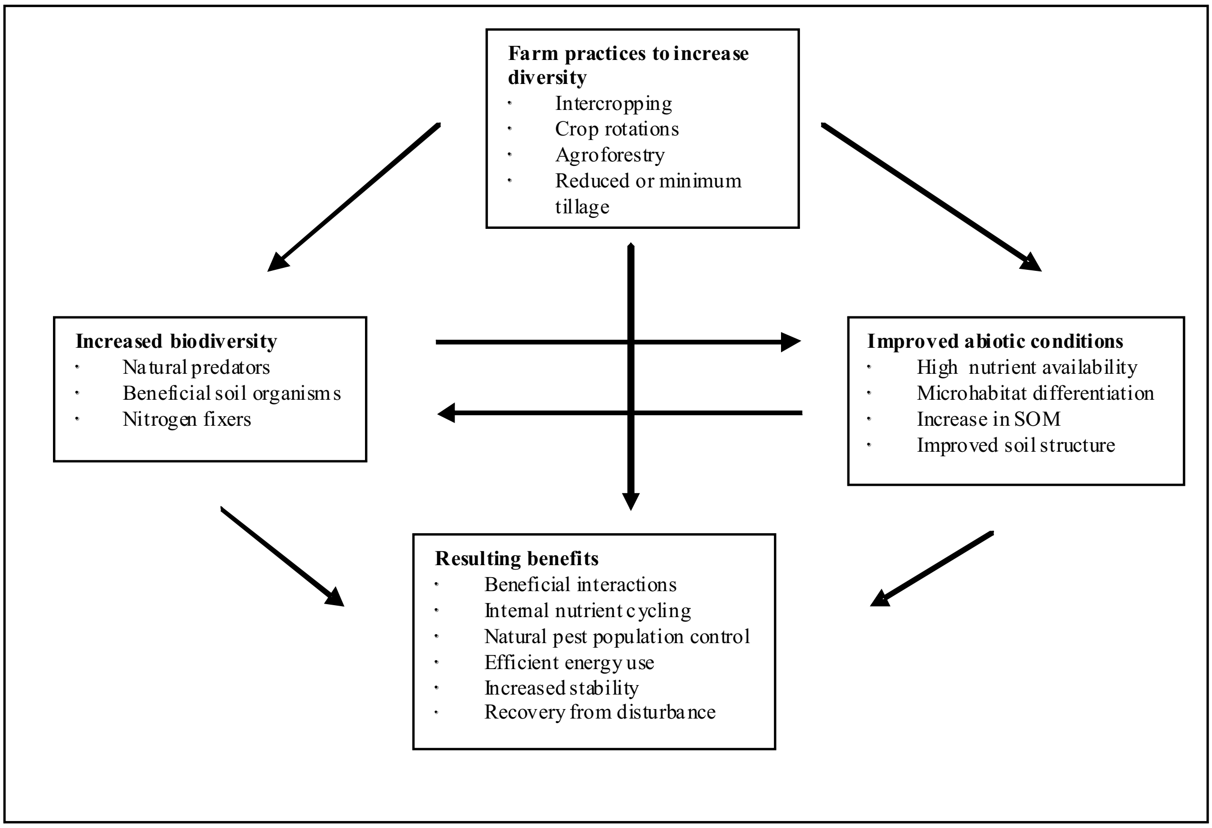

Figure 7.2. Dynamics of managing a diverse agro ecosystem (Modified from Gliessman, 1998)

Box 7.1 Disadvantages of diverse cropping systems

- Diverse systems require increased management skills and timeliness in field operations
- Incompatibility of some chemical pesticides with one or more component crops
- The need for specialized equipment for some systems

Benefits of Diverse Cropping Systems

- Each plant contributes a unique root structure and type of residue to the soil which favours a diverse soil population.
- A diversity of soil organisms can help control pest populations, and a diversity of cultural practices can reduce weed and disease pressures.
- Serves to buffer against disturbance
- Increases stability of a system
- Allows greater efficiency in resource use. Different crops occupy different niches and make different demands on soil nutrients. Managing the complexity of diverse farm system can reduce need for external inputs

- Can contribute to diversity in the surrounding natural ecosystems
- Can positively impact nutrient cycling, regulation of hydrological cycle, and detoxification of noxious chemicals
- Reduces food insecurity and financial risk. If one crop does poorly, food/income from another can compensate

7.4. Soil Quality Assessment

Soil quality assessment is the process of measuring changes in soil over time or space as induced by management or natural processes. The purpose of such assessment is to get information on the direction the soil characteristics are moving, if improving or deteriorating. In agro ecosystems, decisions can then be made to promote management options that improve or cause less damage to soil quality. Soil quality cannot be measured directly, so measurable properties of soil or plants are used as indicators that provide clues about how well the soil can function. Indicators can be physical, chemical, and biological properties, processes, or characteristics of soils. They can also be morphological or visual features of plants. Useful indicators:

- are easy to measure,
- measure changes in soil functions,
- encompass chemical, biological, and physical properties,
- are accessible to many users and applicable to field conditions, and
- are sensitive to variations in management.

Indicators can be assessed by qualitative or quantitative techniques. After measurements are collected, they can be evaluated by looking for patterns and comparing results to measurements taken at a different time or field.

Most soil quality indicators (SQI) require laboratory analysis which can be expensive and time consuming. However, farmers need early warning indicators of soil quality and monitoring tools to guide soil management because the cost of preventing soil degradation is several times less than costs of remedial actions. An important and desirable feature of SQI is their early warning capacity. Since soil degradation is a slow process, it is often that, by the time soil degradation becomes visible (e.g., gullying or low yields), it is already at an advanced stage and recuperation is a slow and costly process. Farmers use SQI (also called local soil quality indicators LSQI) related to crop performance (yield, vigour, leaf colour and sizes, time to flowering), to soil characteristics (colour, workability, depth) or the presence/ absence or abundance of local plant and soil invertebrate species (Barrios et al., 2006). It should be noted that many LSQI integrate multiple aspects of soil quality in a single indicator and they are much more user friendly than complicated laboratory tests. Box 7.2 shows steps in preparation of a scorecard for soil quality assessment for use by farmers.

Box 7.2 Participatory Preparation and Use of a Soil Health Scorecard

Farming communities recognise and assess soil quality using indigenous knowledge which can be integrated with scientific knowledge to contribute to soil quality information. The utilization of visual land quality indicators presents a rapid and efficient manner of appraising land management (Mairura et al., 2007). The dominance of soil texture and soil colour as a differentiating characteristic is common in farmer soil knowledge, which has been shown in some studies to tally formal soil classifications in ethnopedological studies (Talawar and Rhoades, 1997). Indigenous knowledge and scientific information can be integrated into a simple score card for farmers' use.

The purpose of the scorecard is to assess a soil's health as a function of soil and plant attributes as identified by farmers. The scorecard should be a field tool to monitor and improve soil health over time. The score card is best completed near or just following harvest. Periodic and seasonally expressed properties (such as weed species, plant vigour) should be recorded during the growing season. The scorecard has two main sections; the first section questions that describe a specific soil or plant property and the second section is for computing the soil health status of the soil. For each question the farmer indicates a score that best describes the property between, for example, 0-4. Additionally, the farmers may rank the relative importance of each property in relation to crop production. The scores will then be computed in the second section to produce a soil health rating where 3-4 pts corresponds to healthy, 1.5-2.5 impaired, and 0-1 as unhealthy soil.

Below is a list of indicators that can be used in the first section

1. EARTHWORMS **Score**

0 Little sign of worm activity
2 Few worm holes or castings
4 Worm holes and castings numerous

2. EROSION **Score**

0 Severe erosion, considerable topsoil moved, gullies formed
2 Moderate erosion, signs of sheet and rill erosion, some topsoil blows
4 Little erosion evident, topsoil resists erosion by water or wind

3. COLOUR (moist) **Score**

0 Soil colour is tan, light yellow, orange, or light gray
2 Soil colour is brown, gray, or reddish
4 Soil colour is black, dark brown, or dark gray

4. COMPACTION **Score**

0 Soil is tight and compacted, cannot get into it, thick hardpan
2 Soil packs down, thin hardpan or plough layers
4 Soil stays loose, does not pack, no hardpan

5. INFILTRATION **Score**

0 Water does not soak in, sits on top or runs off
2 Water soaks in slowly, some runoff after a heavy rain
4 Water soaks right in, soil is spongy, no ponding

6. SOIL TEXTURE **Score**

0 Texture is a problem, extremely sandy, clayey or rocky
2 Texture is too heavy or too light, but presents no problem
4 Texture is loamy

7. CROP APPEARANCE **Score**
0 Overall crop is poor, stunted, discoloured, in an uneven stand
2 Overall crop is light green, small, in a thin stand
4 Overall crop is dark green, large, tall, in a dense stand

8. SEED GERMINATION **Score**
0 Seed germination is poor, hard for crop to come out of ground
2 Germination is uneven, seed must be planted deeper
4 Seed comes up right away, good emergence

9. GROWTH RATE **Score**
0 Crop slow to get started, never seems to mature
2 Uneven growth, late to mature
4 Rapid, even growth, matures on time

10. YIELD **Score**
0 maize: less than 10 bags/acre, beans: 1 to 2 bags/acre
2 maize: 15 to 25 bags/acre, beans 3 to 6 bags/acre
4 maize: greater than 30 bags/acre, beans: greater than 6 bags/acre

Interpreting soil health scorecard's results

Review the scorecard and count the number of indicator properties that are within the three categories of health listed below. Divide the number in each health category by the total number of questions answered (in our example a maximum of 10) and multiply by 100% for the percentage within each category.

Health Category	Number	%
Healthy (score of 3 - 4)		
Impaired (score of 1.5 2.5)		
Unhealthy (score of 0 - 1)		
Total 100%		

Scorecard users should examine the distribution of indicator properties within the three categories of health. Ideally, one would prefer to see all of the properties score in the *healthy* category. Even if 90% or more of the properties scored are *healthy*, the soil may still have serious problems with the remaining properties. For properties either in the *impaired* and *unhealthy* categories, careful consideration is necessary to identify what caused the property to be in a less-than-optimum condition. *Impaired* indicator properties should be closely monitored over time to determine whether they are deteriorating or improving. *Unhealthy* properties need immediate attention and corrective action. Higher priority should be given to those properties farmers considered more important as indicated by their relative rank.
(Modified from the Wisconsin Soil Health Scorecard as accessed on June 4, 2010
http://www.cias.wisc.edu/wp-content/uploads/2008/07/soilhealth_screen.pdf

7.5 Key Points

- Agrobiodiversity introduces functional diversity of plants, animals and microbes that contributes to ecosystem services such as improved soil quality
- Soil quality is how well soil does what we want it to do
- AGDB ensures long-term agricultural productivity
- Diversity is beneficial for several reasons because each plant contributes a unique root structure and type of residue to the soil.
- Microbial diversity is critical to ecosystems functioning due to the diversity of processes for which microbes are responsible.
- In agro ecosystems, microbes play an important role in nutrient cycling, residue decomposition, soil structure, and pest balance, functions that are critical to the productivity and sustainability of such systems.
- Although it is more difficult to maintain diversity in agro ecosystems, introducing and managing diversity on the farm provides both ecological and economical benefits
- Soil quality assessment is the process of measuring changes in soil over time or space As induced by management or natural processes.
- In agro ecosystems, decisions can then be made to promote management options that Improve or cause less damage to soil quality.

Exercise

1. Using the information given in Box 7.2 develop a soil quality score card that can be used by small scale farmers.
2. How can the scorecard you have developed be integrated as a management tool by farmers?

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Module 8: Economics in Agrobiodiversity

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8.0 Learning Objectives

i. To understand the role of economics in agrobiodiversity
ii. To understand the economic decisions farmers face in agrobiodiversity
iii. To know the challenges in choice of input and farm enterprise in agrobiodiversity
iv. To distinguish between risk and uncertainty and how they affect agrobiodiversity
v. to provide basic record keeping guidelines to help a farmer with agrobiodiversity

8.1 Role of Economics in Agrobiodiversity

The Convention on Biological Diversity emphasizes the link between conservation and commercialization. Conservation of biodiversity becomes a lost cause unless the local people develop a tangible economic stake in conservation to improve their economic status. In this regard, support to production systems providing sustainability or increase in productivity is a dominant criterion. Among the important local economic gains are resilience of crop/commodity against biophysical and economic shocks, changes seen in terms of ability to mobilize assets, and in terms of the range of economic benefits (including both quantitative and qualitative, such as nutritional, health and diversity of productive activities). In addition, there may be components contributing to overall economic gain, which may facilitate wider adaptations for harnessing benefits. For example, efficiency in the use of critical resources, such as land (including biological resources, water, energy, and plant nutrients) human resource, and capital should be recognized as a major criterion. Sustainability can be ensured only by empowering farmers, especially women. Creating an economic stake in conservation by linking the primary conservers with the market reinforces conservation.

Local and national markets for agrobiodiversity production may be developed to increase the value of the products. The identification of "niche markets" and information on the marketing channels that bring the produce to the market can suggest market bottlenecks and constraints. The lack of adequate storage mechanisms and of transportation facilities from field to market, and inadequate supplies of the products are some of the constraints.

In niche marketing, another noteworthy feature of cultivation in geographically dispersed regions is organic production. Organic certification could add value to the products of these regions. Urban consumers looking for dioxin-free organic products and capable of paying premium prices would be the target. Identifying reliable partners/collaborators and developing the capacity for negotiation would be essential. A group-based approach could solve practical issues such as scale of production, transportation and storage. It also would instil and develop collective rationale and foster collective ownership.

The introduction of credit and other facilities could increase supplies and improve the infrastructure. Market constraints might be overcome through promotional campaigns for the products and value addition. Food industry firms should be encouraged to incorporate and promote the products.

Appropriating value to agrobiodiversity species encourages its conservation in a social system for a variety of reasons. Local people have been maintaining and cultivating the genetic resources primarily for their nutritional and medicinal values and out of certain beliefs and faiths and religious rituals, apart from their economic value. Such practices are disappearing in the rural areas due to the changing lifestyle. Their timely promotion at the local level could, however, help in conservation. Women's preferences in crops and varieties are based on their use value such as seasonal food security, culinary tradition and dietary diversity.

Economic benefits of agrobiodiversity are both local and in a wider perspective on environmental services - soil, water and other natural resources conservation; regulation and quality assurance of downstream water supply; interface between local and global biodiversity; carbon sequestration, social and cultural stability, risk factors and poverty alleviation. It is of key importance that the services found beneficial are established as being part of the essential value to the functioning of agricultural ecosystems. Economics at all levels should, therefore, be considered in all decision-making affecting the systems. If the economics of the systems values can be quantified in a sound and convincing manner, institutional arrangements could be found to facilitate payment and other types of returns by external beneficiaries to the local communities or land users.

Production Processes in Agrobiodiversity

The production processes one need to know in agrobiodiversity:

Analysis- involves creating many different products from one source of raw material. If a community is involved in this kind of production, they may find it practical to locate their production nearer to the source of raw material than to the ultimate market.

Synthesis- this is where a single product is constituted from a variety of raw materials. Since the raw materials are an assortment from different locations, farmers should locate the activity near their ultimate market for convenience.

Extraction- occurs when a product is extracted from natural setting, for example timber, extracts from leaves, fruits, flowers or wild plants.

Fabrication- concerns the change in form of some basic material to make it more marketable. This is the essence of value addition.

These processes are more in line with the change in form of a raw product. Where multiple produce is obtained and processing targeted, the producers may add value and improve their market through any of the four processes.

Special Problems of Agricultural Production

Typically, agrobiodiversity is a biological process and such processes have special problems. As farmers engage in them, they need to take note of the following:

Perishability- perishable products must be consumed within a very short time. This affects the location of production and mode of transport.

Bulkiness- determines the type and speed of the mode of transport. To store and haul huge volumes of produce, large spacious modes must be selected. This relates to transport cost.

Seasonality- agricultural production is highly seasonal. During peak season, facilities are often strained in processing and storage. Produce must be processed quickly to prevent spoilage. During low season, facilities remain idle and underutilized.

Variability- agricultural products will vary in quantity and quality. When products are variable, standardization must be done to avoid waste.

Theory of consumer behaviour

The behaviour of a consumer towards a certain product will determine whether it will be produced or not. This is particularly so with agrobiodiversity production.

A consumer's choice of a product depends on their budget. They will choose different combinations of goods which give them more satisfaction than others. They are likely to choose a combination of more of traditional and exotic foods than less. Alternatively, a consumer may choose to consume only traditional food and nil exotic or all exotic and nil local. The factors that influence demand are:

Tastes and preferences: if tastes change so that a consumer gets more satisfaction from a good than before, the consumer will then want to purchase more of that good. Traditional vegetables are an example whose demand has increased in the local market.

Income: An increase or decrease in income can either increase or decrease the demand of a good.

Prices of other goods: The price of one good will affect the demand for another if the goods are substitutes. A fall in the price of one increases its consumption.

Theory of Comparative advantage

The theory of comparative advantage explains that if one region is absolutely more efficient in the production of one good than another region, it is said to have a comparative advantage. It is better if it can specialize in the products in which it has a comparative advantage and then trade with other regions for the goods in which it has disadvantage. Basically, agrobiodiversity is bound to be geographically dispersed depending on agro ecological conditions. Therefore, regions should specialize and export what they have advantage.

Marginal diminishing returns

The marginal principle is explained where two inputs are involved. One input is fixed while the other one varies. When different levels of a variable input are added to a fixed level of input, the addition to product initially increases at an increasing rate. It then increases at smaller quantities, reaches a maximum and then begins to decline reflecting diminishing returns. This is an indication that even if a farmer had free inputs at their disposal, they cannot use them indefinitely. They may use inputs only up to a certain level beyond which they become wasteful.

8.2 Economic Decisions Farmers face in Agrobiodiversity

First, they have objectives to attain: Farmers have multiple goals which have to be prioritized so that when one has been met, effort is made towards the next important goal. Therefore, identification of the best production systems and practices, particularly under low input use should be promoted and conserved.

Second, resources are limited: Goals to be attained are confined within limits set by amount of available factors of production (labour, land, capital and management). Resources may change over time but they are never available in infinite amounts. The level of management skills of farmers is a limiting resource. Identifying current resource limits is the first step in solving them.

Third, alternative uses: Although farmers have limited resources, they have a number of alternative uses for them. Decision must be made on how to allocate resources among alternatives to meet the desired goals.

8.3 Challenges in Choice of Input and Farm Enterprise in Agrobiodiversity

How does a farmer decide how to produce?

The decision on how to produce seems a very difficult one because agricultural products can be produced in many different ways. A farmer may face problems especially where agrobiodiversity is involved. The selection process in crop diversity is a unique traditional knowledge. However, in economics, to reach the correct decision is determined by the appropriate selection the inputs (land, labour, capital and management) to combine. A farmer needs to consider the inputs that will minimize cost of producing a given quantity of output of any of the agrobiodiversity components. From among the many combinations, the farmer will select the one with the least cost. The experience from Bondo case study shows that 56% of farmers used organic manures while 34% did not use any fertilizer while planting local vegetables. This is a good example of combinations of inputs that minimize cost.

A numerical example to help decide on how to produce

Where **two variable inputs** are involved, the most efficient tool for choosing the best combination of inputs to produce a given quantity of product is the input substitution principle. When a farmer uses two inputs it is likely that not both will be increased upwards. The rate at which the added input substitutes for the replaced input is termed as marginal rate of substitution (MRS). Therefore, MRS shows the amount of units of replaced input divide by units of added input. In the Bondo case study, famers substitute organic manures and no fertilization at all for inorganic fertilizers. The rates at which replacements are made can be estimated in order to determine the best combination under farm conditions.

The table below shows the combination of manures and nitrogen to produce a certain amount of product. Given the price of nitrogen is £30 per unit and manure £75 per unit, then, the MRS by dividing change in manure added by change in nitrogen given up.

Table 8.1. Computation of marginal rate of substitution (MRS)

Manures (Kg)	Nitrogen (Kg)	MRS
1316	1000	
1259	1100	(57/100) = 0.57
1208	1200	(51/100) = 0.51
1162	1300	(46/100) = 0.46
1120	1400	(42/100) = 0.42
1081	1500	(39/100) = 0.39
1046	1600	(35/100) = 0.35
1014	1700	(32/100) = 0.32
984	1800	(30/100) = 0.30
957	1900	(27/100) = 0.27
932	2000	(25/100) = 0.25

The Inverse Price Ratio (IPR) is calculated as follows: The price of added input divided by the price of replaced input as follows: 30/75 = 0.4

The least cost combination of inputs occurs at the point where MRS=IPR and this occurs at 1120 units of manure and 1400 units of nitrogen.

The practical application of this concept is to determine the point where the farmer must produce in order to eliminate wasteful combinations. These calculations may be done for farmers by extension officers.

How much should a farmer produce in agrobiodiversity?

Even with agrobiodiversity, a farmer does not have an infinite capacity to produce any given quantities of output. The amount produced is determined by the number and levels of inputs used. The levels of how much to produce can be determined by using marginal analysis.

Marginal means "additional". To know how marginal is arrived at, the following terms must be understood:

Total Product is the total output obtained from using a certain level of inputs. Marginal Product is the additional output from each added unit of input. When a price is placed on these outputs it becomes value of product. Marginal input cost is change in total input cost divided by change in input level.

The illustration below is used to determine how much a farmer can produce with a given level of input. Assuming the following prices: Input price is £12 per unit and output £2 per unit, then the calculations may be done as shown in table 8.2.

Given the levels of input, output, and their prices, the point that defines how to produce occurs where the Marginal Value Product equals Marginal Input Cost (MVP=MIC). This means that with the given input, the amount of output the farmer must produce is 68 units and the amount of inputs to use is 6 units. That point is the most profitable use of the input.

Table 8.2. Computation of the amount to produce given a certain level of input

Input Level	Total output (TP)	Added output (MP)	Value of Output (TVP)	Value of added output (MVP)	Additional input cost (MIC)
0	0		0		
1	12	12	24	24	12
2	30	18	60	36	12
3	44	14	88	28	12
4	54	10	108	20	12
5	62	8	124	16	12
6	68	6	136	16	12
7	72	4	144	8	12
8	74	2	148	4	12
9	72	-2	144	-4	12
10	68	-4	136	-8	12

Practical application

Farmers often use between 0 and 3 bags of fertilizer per acre. Using average yields for each level and given local input prices, this point can easily be calculated by extension officers.

Alternative approach is to calculate the marginal cost and marginal revenue. Assuming the following prices: Input price is £12 per unit and output £2 per unit, then the calculations may be done as follows:

Input Level	Total Output (TP)	Added Output (MP)	Total Revenue	Marginal Revenue	Marginal Cost
0	0		0		
1	12	12	24	2.0 (24/12)	1 (12/12)
2	30	18	60	2.0 (36/18)	0.67 (12/18)
3	44	14	88	2.0 (28/14)	0.86 (12/14)
4	54	10	108	2.0 (20/10)	1.20 (12/10)
5	62	8	124	2.0 (16/8)	1.50 (12/8)
6	68	6	136	2.0 (12/6)	2.0 (12/6)
7	72	4	144	2.0 (8/4)	3.0 (12/4)
8	74	2	148	2.0 (4/2)	6.0 (12/2)
9	72	-2	144		
10	68	-4	136		

Marginal revenue is the change in total revenue divided by change in total product and Marginal cost is the change in input cost divide change in total product. When this approach is used, the same point as above is reached. The profit maximizing level of output is where Marginal Revenue = Marginal Cost. This coincides with input level of 6 units and the best level to produce is 68 units of output. At that level marginal revenue is £2 and marginal cost is £2. Any point outside this will not be optimal.

What to produce (Diversity/Combination of Enterprise)

Given agrobiodiversity, a choice must be made from among all possible enterprises in the household. It involves selecting the combination of crops and livestock to be produced. Should a farm produce crops only, livestock only or combination? Which crops? Which livestock? The farmer must select from among many alternatives that combination which best meets the goals.

Competitive enterprises

This is a likely scenario in agrobiodiversity. When enterprises compete for the use of the same limited input at the same time, then it is easier to make a decision. The expansion of one output can only come by diverting inputs from one enterprise to the other. For example, this might occur when trying to allocate labour among cattle and weeding. The most profitable combination of two competitive enterprises can be determined by comparing the substitution ratio and the price ratio. The profit maximizing combination of two competitive enterprises occurs where Substitution Ratio = Price Ratio

Supplementary enterprises

Two enterprises are supplementary if the production of one can be increased without affecting the production level of the other. For example if two enterprises need the use of *jembes* and both are done at the same time, they will compete for the implements, but if they are produced at separate times, they do not compete. If a farmer has agrobiodiversity enterprises exhibiting such relationships, they should take advantage of supplementarity and produce both products at least to the point where the products become competitive. The exact point depends on the substitution and price ratio

Complementary enterprises

Many agrobiodiversity enterprises tend to show complementarity. Enterprises are complementary whenever increasing the production from one enterprise causes the production from the other to increase at the same time. For example, rotating legumes with other crops. Legumes improve soil leading to increased yields from other crops. If such a relationship exists in agrobiodiversity, then complementary enterprise should be increased to at least a point where the production of the primary product is at maximum. The exact point depends on the substitution and price ratio.

Joint Enterprises

Products which result from the same production process are termed as joint products. They include such combinations as milk and cheese, beef and hides, or cotton and cotton seed.

Box 8.1 Yields and Profitability of Traditional Vegetables, Maize and Sorghum in ¼ acre monocrop in Bondo

Type	Yield (Kg)	Bunches (0.7 kg)	Farm gate price	Market value	Prod Cost	Gross Profit
Spider plant	900	1286	5	6,428	800	5,628
Cowpea	766	1094	5	5,471	800	4,671
African nightshade	798	1139	5	5,697	800	4,897
Maize	90	-	1,200	1,200	1,500	-300
Sorghum	180	-	1,400	2,800	1,050	1,750

Given the gross profits from different enterprises, farmers either combine several of them or may produce only one of them. The choice will be decided based on the explanations provided above (Source: Mungai, *et al*., 2008).

8.4 Farmer Risk and Uncertainty in Agrobiodiversity

Agrobiodiversity is bound to face risk and uncertainty. The types of risk and uncertainty include: production, technical, price, financial. A risk is when the outcome of the production process is a random variable with known probability or the probability can at least be estimated. Uncertainty exists when the probabilities associated with an outcome of a production process are unknown.

There is need to reduce risk in agrobiodiversity by reducing variability over time and to ensure minimum income level to meet family and other expenses.

Strategies to Combat Risk and Uncertainty

Flexibility

Flexibility means the ability to shift from one farm enterprise to another. A farmer with agrobiodiversity is more likely to make adjustments in the farm operation in response to changing conditions in order to reduce disruptive fluctuations in income. The most appropriate enterprises that can be shifted when necessary are seasonal and annual enterprises. Farmers may construct structures that are convertible from one enterprise to another within a short notice.

Diversification

Diversification is the raising of different enterprises on the same piece of land. A good example of diversification is agrobiodiversity. When various enterprises are raised, their prices and yields vary and are not likely to fluctuate together. Diversification would produce a more stable income than one enterprise. However, too many different enterprises reduce the efficiency of the farmer.

Management of production

Failure to follow good management practices and techniques are a source of poor outcomes. Farmers would eliminate some sources of production risk by using appropriate practices.

Marketing strategies

A farmer does not need to produce enterprises that mature at the same time. Staggering out the enterprises over the seasons spreads sales over most of the year.

Box 8.2 Analysis of Risk Situations

Agricultural production processes involve inputs controlled by the farmer as well as inputs beyond their control. Uncontrollable inputs may be random variables such as those controlled by nature and they may be non random as regulations by government agencies or set by economic forces beyond the farm. When controlled and uncontrolled combine in the production process, we say there is interaction. Where interaction exists, then a farmer has a certain degree of control over the production process. However, without interaction, the production response will not vary regardless of the amount of inputs.

8.5 Basic Records

When agrobiodiversity is engaged, it is worthwhile to keep basic records. The importance of records

(i) records show the farmer which enterprises are making losses and which ones are returning the most from inputs

(ii) records provide basis for judging performance

(iii) records helps to control theft or loss of cash or stocks

A simple record keeping for farmers should have basically two columns; one for receipts and another for expenses. The format provided below should be made for individual enterprises. The farmer can multiply the output with price to obtain revenue then subtract costs to determine loss/gain.

Table 8.3 An example of a record- keeping form

Expenses (Costs)	KES	Receipts (revenue)	KES
Plough Seed Weeding Harvesting Others costs		Total output x Price	
Total cost		Total revenue	
Loss or Gain			

Partial budget

A partial budget is the simplest form of a budget. It is used when a farmer wishes to determine the financial effects of fairly minor changes in farm organization. Partial budget can be used under three circumstances:

i) when a farm wants to adopt a new enterprise/technique

ii) when a farmer wishes to replace an enterprise with another

iii) when an expansion of an enterprise is anticipated.

Irrespective of the activity, a partial budget will have the following format

Additional Costs	Costs Saved
Revenue Forgone	Extra Revenue
Totals	Totals

Illustration

The information provided was obtained from a farmer in Olenguruone, Kenya.

A farmer in Olenguruone has 10 acres of land, 4 acres have been planted a permanent crop (tea). Of the remaining 6 acres, at least one half must be resting at any one time. This year, he intends to open up 3 acres for sunflower. With a previous crop, he hired casual labour at the rate of 40 man days per acre at shs 100 per man day. He is considering replacing casual labour with a hired tractor doing the work at shs 1100 per acre. The farmer anticipates that by using the tractor, there will be an increase in average sunflower yield from 7000 kg to 8000 kg per acre. The sunflower would fetch KSh 10 per kg. Harvesting cost would be shs 1000 per 1000 kg of sunflower seed.

Prepare the partial budget and advise the farmer whether the change is worthwhile or not.

Partial Budget

<u>Additional costs</u>		<u>Costs Saved</u>	
Tractor cultivation @1100/= for 3 acres	3,300	40 man-days for 3 acres @100 per man-day	24,000
Harvesting (1000/= @ 1000 kg x 3 acres)	30,000		
<u>Revenue Forgone</u>		<u>Extra Revenue</u>	
Nil		1000 kg/acre for 3 acres @ 10/= per kg	30,000
Totals	33,300	Totals	54,000
Net Gain	20,700		
	54,000		54,000

There is a net gain of K Shs 20,700. Under the present circumstances, the change represents a net gain and therefore, worthwhile.

8.6 Application of Economic Principles

The application of economic principles is absolutely essential when farming is viewed as a business, and not as a way of life. However, the uptake of the principles by farmers depends among others on: the education level, the objective of farming, their age, gender, and their perception (Box 8.3). It has been established that when farmers perceive a technology to be complex, it decreases the rate and speed of adoption (Batz, et al., 1999). Education of decision makers influences adoption positively. The more educated a household is, the more likely it is to adopt technologies (Lagat, et al., 2003).

Box 8.3 Uptake of Agrobiodiversity in Bondo

Survey results indicated that whether mono-crop or inter-crop, female farmers formed the bulk of both practices. This implies that the gender of an individual is likely to influence the cropping system of local vegetables. This could be a cultural problem where vegetable growing is a domain of women.

The age of the farmers showed that younger farmers were more likely to practice inter-cropping while the older ones tended to prefer mono-cropping. Farmers tended to be rational because intercrops are more demanding in terms of labour and skill.

Most of those with secondary and primary education engaged in both cropping systems. However, a higher number of individuals without any form of education engaged in mono-cropping than in inter-cropping. The less educated are likely to view intercrops as a complex practice and would not adopt it.

Source: Mungai et al., 2008

8.7 Key Points

- Agrobiodiversity becomes a lost cause unless the local people develop a tangible economic stake in conservation to improve their economic status.
- Through several ways, local and national markets for agrobiodiversity production may be developed to increase the value of the products through the identification of "niche markets" and information on the marketing channels that bring the produce to the market.
- The application of economic principles absolutely essential when farming is viewed as a business, and not as a way of life. There are principles that guide in selection, combination, and profitability of different enterprises.
- Agrobiodiversity is an agricultural activity, and faces risk and uncertainty. However, these risks can be minimized.

Exercises

1. Participants to list down on flip chart/flash cards some of the production problems facing farming households.

2. a) In what ways and in what format can economic concepts be introduced to farmers?
   b) Farmers often complain they do not have time for records? Suggest solutions to this problem

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Module 9: Uptake Pathways for Agrobiodiversity (AGBD) Technologies

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9.0 Learning Objectives

At the end of this module the trainee is expected to have better understanding of:

i. The uptake pathways to promote AGBD technologies
ii. The barriers to uptake of AGBD enhancing technologies

9.1 Why Promote Agrobiodiversity Technologies

The AGBD in many agroecosystems is under threat including the local knowledge, culture and skills of indigenous people who have maintained it. The scale of the loss is extensive for harvested species, varieties and breeds and a wide range of harvested and non harvested species. Since the 1900s, some 75 percent of plant genetic diversity has been lost because farmers worldwide have left their local varieties and landraces for genetically uniform, high-yielding varieties. This is affecting the ecosystem functioning and services like pollination and pest control, nutrient cycling, greenhouse gas exchanges, water use efficiency, soil structure formation, and resistance and resilience of communities. The rapid loss of AGBD necessitates promoting uptake of AGBD technologies to enhance sustainable use and conservation of harvested and non harvested species, varieties and breeds of crops and livestock that are rapidly disappearing from smallholder farming systems. There are multiple benefits in promoting uptake of AGBD technologies (Box 9.1).

Box 9.1 Benefits Associated with Promoting AGBD

- Increase productivity, food security, and economic returns
- Reduce the pressure of agriculture on fragile areas, forests and endangered species
- Make farming systems more stable, more robust, and sustainable
- Contribute to sound pest and disease management
- Improve soil fertility and health
- Contribute to sustainable intensification
- Expand options for products and income opportunities
- Reduce risks to individuals and nations
- Enhanced effective use of resources and the environment
- Reduce dependency on external inputs
- Restore and sustain human nutrition and sources of medicines and vitamins, and
- Maintain ecosystem structure and stability of species diversity

9.2 Uptake Pathways for AGBD Enhancing Technologies

Conceptual pathways enhancing uptake of AGBD technologies

New conceptual paradigms are emerging for promoting AGBD technologies to narrow the gap between development and research priorities and farmers' needs. One new concept is sustainable livelihoods framework, introduced to help explore the linkages between AGBD, gender and local knowledge. Sustainable livelihoods framework is people-centred analysis in which people's assets are embedded in assessing AGBD and its potential contribution to people's livelihoods, people's vulnerability context, existing policies, institutions and considers the processes as well. It considers the different livelihood strategies and outcomes (food security, health issues, and pest management strategies) that strongly determine how these assets can be used. The merits of using a livelihoods perspective over the natural resource management perspective for uptake of AGBD enhancing technologies are compared in Box 9.2.

Box 9.2 Merits of Using a Livelihoods Perspective over the Natural Resource Management Perspective for Uptake of AGBD Enhancing Technologies

Livelihoods perspective	**Natural resource management perspective**
● Focus is on local people and their livelihood strategies	● Focus is on genetic resources and their production potential and use
● Holistic in terms of understanding the purposes and functions played by AGBD in livelihood strategies	● Narrow in terms of understanding and strengthening different purposes and functions of AGBD
● Dynamic in terms of changing priorities and needs of different people at different times	● Static resulting from the pre-selection of priority species for improvement and conservation
● Builds on people's strength, e.g. Local knowledge for species selection and *in-situ* conservation practices	● Draws heavily on external knowledge and technologies for species improvement, including *ex- situ* conservation practices
● Macro-micro linkages, e.g. Policy lobbying for Farmers' Rights to secure local access to genetic diversity	● Tends to focus more on either natural resource level or policy level
● Sustainability related to improved local capacities and empowerment of Local people	● Sustainability questionable because little attention is given to building Local capacities

Campaign awareness pathways

Agricultural shows such as seed and breed fairs and exhibitions where farmers exhibit and exchange different breeds and varieties and sometimes compete for the greatest number have proved successful uptake pathways for AGBD enhancing technologies. When combined with participatory breeding and exchange mechanisms for AGBD, they motivate young people to participate and involve a larger section of the community in mapping of diversity at village level. In such exhibitions, farmers obtain information on valuable and unique attributes of the available indigenous crops and livestock breeds and varieties that are usually ignored or not understood. Agricultural show and exchange visits offers an opportunity for farmers to earn income and learn of new AGBD technologies for eventual adoption because of increasing interest on rare breeds and neglected species such as camels, buffaloes and donkeys, or yaks, as illustrated in Figure 1.

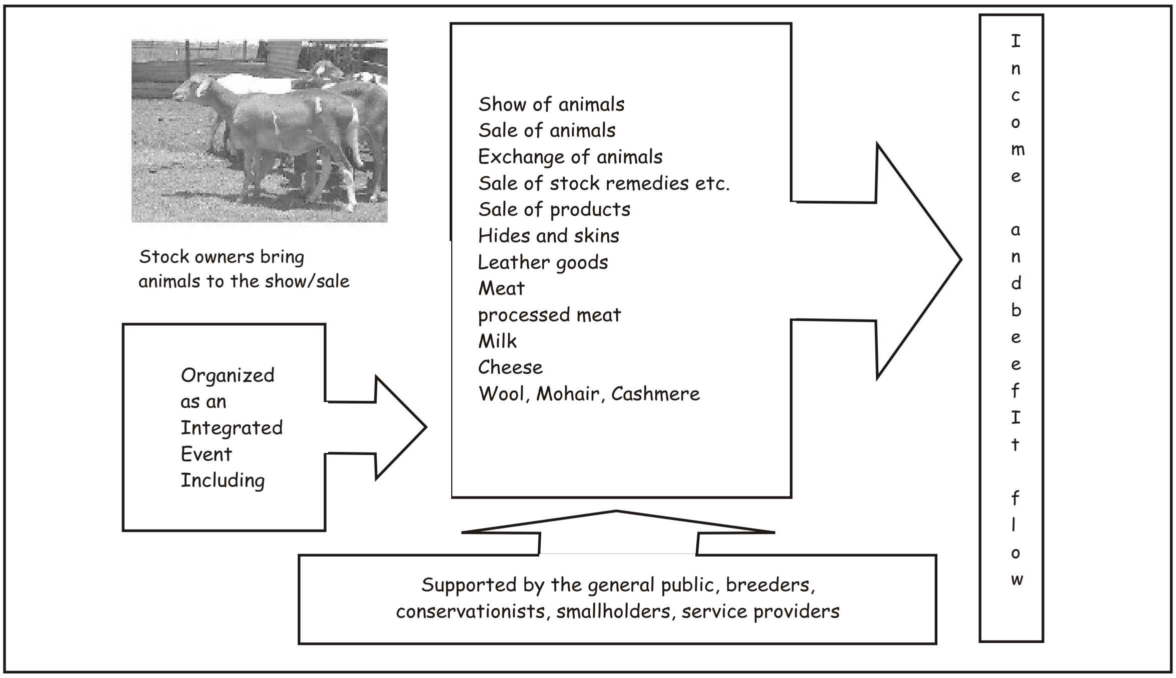

Figure 1. Income and benefit flow from agricultural exhibition of AGBD (Source: Almekinders, 2002)

Protection pathways

Protection pathways for AGBD enhancing technologies are international legal instruments bidding the member state signatories. Exemplifying this is the Convention on Biological Diversity (CBD), which is stated in Box 9.3. The instrument recognizes the role of local and indigenous communities in the conservation and sustainable use of biodiversity, and their right to be consulted when their biodiversity or their related knowledge and technologies are used by others. It also recognizes that those using the biodiversity or technologies should give a fair share of the benefits arising from the use to the local and indigenous communities. It expects countries to provide incentives to those who conserve and sustainably use AGBD and hence to their local or indigenous communities. Any state can thus legally recognize Farmers' Rights as a set of rights that the farming community itself recognizes as its own under its own customary (usually unwritten) laws.

Box 9.3: The Convention on Biological Diversity (CBD) Articles

The Convention on Biological Diversity (CBD) Articles requires its member state signatories to respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant to the conservation and sustainable use of biological diversity, and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of benefits arising from the utilization of such knowledge, innovations and practices. It commits signatories protects and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with the conservation or sustainable use requirements.

(CBD: www.cbd.int/convention/convention.shtml)

Farmers' Rights are vested in the international community in order to:

- Ensure that the need for conservation is globally recognized and that sufficient funds for these purposes are availed;
- Assist farmers and farming communities, in all regions of the world, but especially in the areas of origin/diversity of plant genetic resources, in the protection and conservation of their plant genetic resources, and of the natural biosphere;
- Allow farmers, their communities and countries in all regions, to participate fully in the benefits derived, at present and in the future, from the improved use of plant genetic resources, through plant breeding and other scientific methods.

Market pathway approaches

Marketing strategies for commercializing AGBD thrive on consumers' increasing awareness of health and environmental issues linked to the unique and useful attributes of the natural products. AGBD products meet the demands for healthy and quality products, appeal to consumers wanting products produced in ecologically (ecosystem homeostasis) and socio-economically (fair trade) sustainable way. The farming communities can realize the market benefits by forming market promotion inter-linkages with processors and retailers to reach a wider consumer network at reduced costs. A community marketing efforts applicable to AGBD marketing approaches is illustrated in Figure 2.

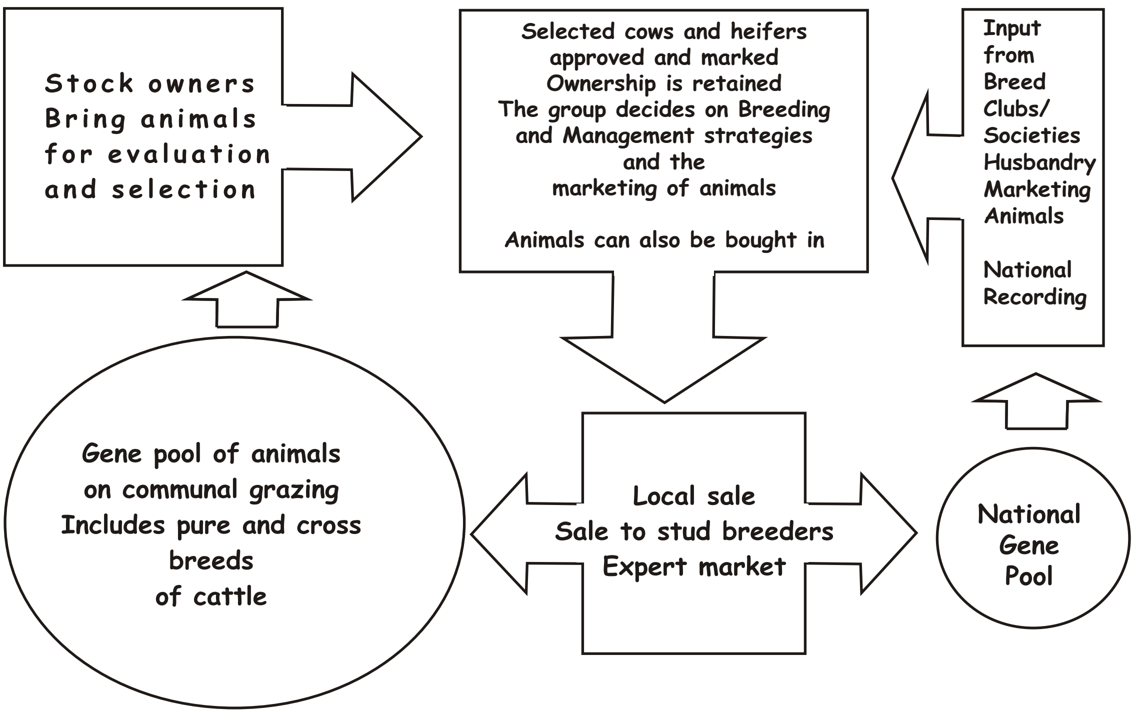

Figure 2. Marketing approaches to enhancing uptake of AGBD technologies (Almekinders, 2002)

Organic products have a growing market niche that farming communities can exploit as evidenced by a variety of organic products traded globally (Table 9.1). Affiliation to certification organization is a means to enhance market promotion of the AGBD products.

Table 9.1. Main organic products traded internationally

Fresh fruits and vegetables	Dried fruits and nuts	Processed fruits and vegetables
Coffee, tea and cacao	Spices and herbs	Oil crops and derived products
Sweeteners	Cereals and grains	Dried leguminous vegetables (pulses)
Meat, dairy products, eggs	Alcoholic beverages	Processed food and food preparations

Carbon market trade

Carbon trading is based on polluter pays principle with the goal of establishing a charge for the right to pollute. The concept encourages businesses to reduce their emission of CO_2, the worst and most abundant pollutant, by investing in clean technologies as a means to reducing greenhouse gases. The participating company is allocated a quota which, if it exceeds, it must pay either a fine or buy emission credits from a farmer. Carbon trading market encourages communities to re-orient their farming practices and concepts such as not tilling fields, leaving soil cover permanently covered with mulch or crop residues. In doing so, they prevent carbon dioxide buried in the soil from escaping into the atmosphere. The resulting tones of trapped carbon dioxide are paid for by a company that produces carbon dioxide into the atmosphere, thus compensating for the quantities it produces.

This carbon trading offers farmers in the developing countries opportunities to earn income from their efforts to reduce emissions of greenhouse gases while adapting their farming methods to mitigate climate change. It is a key instrument in Kyoto Protocol for combating the greenhouse gases that cause global warming, and it is creating a flourishing carbon market, especially in the European Union. Countries signatory to Kyoto Protocol that came into force in 2005, have pledged to cut their emissions of six greenhouse gases by 5.2% compared to 1990 base situation between now and 2012. In 2006, 493 MT of CO_2 were traded, representing a 30% rise on 2005 base situation. The price of carbon varies according to supply and demand, with prices of €5 to €12 per tonne. With this approach, business firms in industrialised countries fund projects in developing countries which are designed to reduce emission of greenhouse gases into the atmosphere.

A scheme similar to carbon trade is payments for environmental services approach to encourage reforestation on private land. Benefits of environmental services are paid to farmers by the donors, who enjoy the services.

Promotion and support of community based uptake of AGBD technologies

Community based activities are of special uptake pathways for AGBD enhancing technologies because management of AGBD in rural farming systems can only be achieved by involving local people and their communities (Thies, 2000). Community-based activities in the seed multiplication, seed banks, participatory breeding and seed exchange mechanisms have proven contributions as an answer to the unsatisfactory solutions modern agricultural research offered to resource poor farmers. A greater diversity of crops and varieties is part of their risk avoiding strategy. NGOs are the major active players in support of community based activities in AGBD.

Farmer Field Schools (FFS) is a participatory extension approach of collaboratively working with farmers in their fields to improve their knowledge and skills of integrated management of AGBD for sustainable agricultural systems. Impact studies show that FFS implementation significantly enhances farmers` knowledge and skills about the technologies disseminated. FFS could be effectively used to train trainers who in turn train farmers. The FFS encourages farmers' participation in formulating their agenda, the content and the dissemination pathway. With FFS, both extension officer and the farmer learn from each other, share experiences and set own targets and goals. The FFS training environment allows for relating AGBD to both natural resources conservation and production. It is an approach to reorient the recreation of farmers' multifunctional cropping systems and agro-ecological management with the AGBD agenda.

Participatory approaches based on community knowledge and capacities have been applied in plant breeding and selection. Researchers work together with farmers on development of useful new breeds and varieties of crops and livestock, encouraging farmers to adopt them in addition to their AGBD and not replacement. The approach has been used to promote farmers' access to quality seed by organizing farming communities based small scale seed production and selection gardens. Seed gardens have proved effective in proving reliable source of good quality seed; improving seed management and production opportunities, seed quality and health; and in enhancing the use and conservation of AGBD by farmers on their farms for specific needs. When farmers multiply the seeds they improve seed security and the diversity through open pollination while earning income.

9.3 Barriers to Uptake of AGBD Enhancing Technologies

Paradigm of modern agriculture

The paradigm of modern agriculture encourages destruction of natural environments and the use of varieties with a narrow genetic base and leads to decrease of support for the organisations that conserve plant genetic resources *ex-situ*. There is a preference for monoculture with genetically uniform varieties and abandonment of multi cropping and intercropping with a range of species, microclimate management and fields with mixed varieties and landraces.

Modern animal breeding tends to emphasise the development of superb animals rather than maintaining genetic diversity within a breeding population (Tewolde, 2001; Tewolde, 2002) Support for indigenous breeds is scarce and seldom different breeds of one species are promoted. Modern agriculture is slowing implementation of FAO's Global Plan of Action (GPA) for the conservation and use of plant genetic resources that presently lags far behind the schedule. Speeding up the implementation of GPA requires practical demonstration of the benefits of AGBD for present and future generations.

Demonstrating the benefits of AGBD is very important for the justification of policy or funding decisions. Possible areas to demonstrate benefits of AGBD include health, nutrition, food security and food sovereignty, ecological sustainability or cultural identity. A key question, therefore, is how can both “modern” agriculture and sustainable production methods that enhance and protect diversity coexist and interact to their respective advantage? Modern agriculture or industrialized production systems today need to be altered in a way that they conserve and manage AGBD in a sustainable manner. The separation between production and conservation must be overcome through identification of where production and conservation go hand in hand and where their impact suit AGBD protection and development.

Safety of AGBD conservation

Safety of AGBD conservation technologies is a concern in plants but not in animals. Natural catastrophes such as hurricanes, floods, or armed conflicts can wipe out the genetic diversity of a large area. A backup system in gene banks provides some security. In using gene banks, a regular renewal of material on farmers' fields where it originated or where conditions are similar would make the *ex-situ* collections safer, enhance farmer-scientist relations and allow adaptation of the gene bank material to the environment.

The geographic origins of resistant genetic material are often `hot spots´ where both pathogen and host are present with a large and evolving diversity. Sampling the host captures the resistance at that time but stops the evolutionary process. *In-situ* conservation ensures that host and pathogen evolve together. The speed of this change determines how much *in-situ* conservation is needed and how long a sample could rest in a gene bank without being in danger of losing the appropriate resistance, besides its viability. Farmers or communities should be encouraged to use and freely experiment with genetic material which will give a good indication as to what they really need and where they see potentials.

Barriers in AGBD access and benefit sharing

Clear and practical guidelines on AGBD access and benefit sharing are not in place and remain a major battleground between the providers and the users of AGBD resources. The CBD does not make any provisions as to how benefit sharing mechanism should be achieved. The organisations involved in the discussion of policy guidelines have concentrated on theoretical or policy level but activities and programmes that tackle the question at a practical level are rare.

Many national seed legislations are barriers to the free exchange of seeds and the use of landraces and farmers´ varieties, with many WTO members opting for the Intellectual Property Rights (IPR) regime that allows patenting of plant varieties and animals. Legal protection options are mostly preferred by the very active and potent lobby organisations that support the interests of plant breeding companies and multinational life sciences corporations that favour patenting.

Breeding laws often put indigenous farm animal breeds at a disadvantage. Licensing of sires and herd books are intended to make sure that breeds are further developed according to breeding objectives. Particularly where artificial insemination is favoured this can lead to a reduction of genetic diversity within a breed, and sires for artificial insemination are normally so-called exotic breeds. NGOs are generally supportive of the idea that genetic resources should remain in the public domain and critical of development of a more stringent ownership system like patenting. They advocate for a farmer friendly, legal regime that allows public or community ownership because a big concern of the implications for the South and its food security. However, less of the efforts of NGOs have found their expression in a clear stand against WTO regulations, bio piracy or national policies.

Globalization of the food system and marketing

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.

Unfavourable policies

Development policies in favour of introduction of exotic germplasms undermine indigenous knowledge and value and encourage erosion of indigenous genetic resources and knowledge. Public agricultural research and extension institutions narrowly focus on promoting introduced exotic germplasms which largely act as disincentives for conservation and sustainable use of AGBD (Ursula et al., 2001). Land use planners often are aware of their influence on wildlife diversity but probably less aware of their influence on AGBD, especially the diversity of crops and breeds. Whether small farms or large commercial enterprises are given priority, whether organic farming or conventional agriculture are practiced or whether forestry and wildlife are incorporated in land use planning, such decisions influence the range of genetic diversity of an agro-ecosystem, but often do not include AGBD as an element in their activities.

9.4 Key Points

- There are multiple ecological, economic and societal benefits in promoting uptake of AGBD technologies.

Many AGBD uptake pathways are available including:

- Adopting a livelihoods perspective over the natural resource management perspective;
- Agricultural exhibitions by farmers combined with participatory breeding and exchange mechanisms of their rich AGBD
- Implementation of national and international legal instruments such as Convention on Biological Diversity (CBD)
- Marketing AGBD to consumers on the attributes of health and eco-services
- Promotion and support of community based uptake of AGBD technologies like Farmer Field Schools

The barriers to uptake of AGBD enhancing technologies that require overcoming are:

- The paradigm of modern agriculture that encourages destruction of natural environments and use of narrow genetic base
- Complex issues of access and benefit sharing of AGBD
- Globalization of the food system and marketing
- Development policies favouring introduction of exotic germplasms undermine Indigenous knowledge and value and encourage erosion of indigenous genetic resources and knowledge

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Exercises

Choose any two AGBD technologies familiar to you; one with application to crops and another with application to livestock components of AGBD then discuss the following:

a) Who are the target beneficiaries of the technology?

b) To what extent (low, average, and high) have the target beneficiaries adopted the technology?

c) Identify incentives and disincentives for the adoption of the technology

d) Suggest some approaches to remove the disincentives for the adoption of the technology

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Module 10: Climate Change and Agrobiodiversity

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10.0 Learning Objectives

By the end of the module the participants will have understood and appreciated the issues on:

i) Climate change in the context of agrobiodiversity;
ii) Effects of climate change on agrobiodiversity, and
iii) Mitigation against the effects of climate change on agrobiodiversity.

10.1. Introduction and overview

Climate change and global poverty are issues of great concern currently as key global challenges. The future health and prosperity of mankind is dependent on managing these two phenomena simultaneously as one cannot be taken care of without addressing the other. An effective attack on poverty and the ill-effects of climate change requires taking comprehensive action that encompasses both issues (End Poverty 2015 Millennium Campaign, 2000)

Farming is becoming more difficult and risky due to the unpredictability in the timing and pattern of rainy seasons, making it difficult to plan farm operations (tillage, planting, weeding and harvesting). Consequently, farming now requires more resources. Some of the serious problems associated with climate change include heat stress, lack of water at crucial times, and increase in pests and diseases (Reid et al., 2009).

Awareness about the close relationship between climate change, food security and the role of agrobiodiversity has to be raised. Notably for subtropical regions, climate induced environmental changes will have severe implications for agriculture and for food security. Agrobiodiversity plays a key role to cope with this challenge (Kotschi, 2006).

10.2. Indicators of climate change

Climate change in much of the tropics will be manifested in increased frequency and severity of drought, which calls into question the fundamental sustainability of agricultural diversity as a source of livelihood. More localized projections are emerging every day, for instance, the arid and semi-arid lands (ASALs) of Kenya are likely to experience decreased rainfall in the medium-term (Osbahr and Viner, 2006), but longer or more intense rainy seasons in the longer term (Nassef et al., 2009). Further projections ascertain that arid and semi-arid grazing systems in East Africa are seen as highly vulnerable to climate changes (Jones and Thornton, 2006). More generally, there is an assumption that AGBD face an increased risk of drought events, due to increased variability of rainfall with higher temperatures, even if mean rainfall is predicted to rise. Consequently, the strong trends in climate variability is already evident, the likelihood of further changes occurring is huge, and the increasing scale of potential climate impacts give urgency to addressing the effects on AGBD more coherently (Nori and Davies, 2007).

Over the last several decades, evidence of human influences on climate change has become increasingly clear and compelling. Human activities such as electricity production and transportation are adding to the concentration of greenhouse gases that are already naturally present in the atmosphere. These heat-trapping gases are now at high levels in the atmosphere. Warming of the climate system is an increasing phenomenonwith build-up of greenhouse gases in the atmosphere being the most likely cause of most of the recent observed increase in average temperatures, and contributes to other climate changes.

Collecting and interpreting environmental indicators plays a critical role in understanding of climate change and its causes. An indicator represents the state of certain environmental conditions over a given area and a specified period of time. Environmental indicators, including those related to climate change are used to help track trends over time in the state of the environment. Some of the common indicators according to EPA (2010) include:-

Greenhouse Gases: The important aspects here include; the amount of greenhouse gases emitted into the atmosphere through human activities, the concentrations of these gases in the atmosphere, and how emissions and concentrations have changed over time.

Weather and Climate: The indicators are related to weather and climate patterns and include; temperature, precipitation, storms, droughts, and heat waves. Long-term changes in the earth's climate system can easily be revealed by these indicators.

Oceans: The world's oceans have a two-way relationship with climate. The oceans influence regional and global climates. Changes in climate can fundamentally alter certain properties of the ocean such as acidity, temperature, heat storage, and sea level.

Snow and Ice: Climate change can dramatically alter the earth's snow- and ice-covered areas such as Mt. Kenya and Mt. Kilimanjaro in East Africa. These changes, in turn, can affect air temperatures, sea levels, ocean currents, and storm patterns. Understanding the trends in glaciers; the extent and depth of snow cover; and the freezing and thawing of oceans and lakes is of paramount importance in predicting impacts on agriculture and AGBD.

Society and Ecosystems: Changes in the earth's climate can affect public health, agriculture, energy production and use, land use and development, and recreation. Climate change can also disrupt the functioning of ecosystems and increase the risk of harm or even extinction for some species. The impacts directly related to climate change include heat-related illnesses and changes in plant growth among others.

Drought: Over the period from 2001 through 2009, roughly 30 to 60 percent of the USA land area experienced drought conditions at any given time. However, the data for this indicator have not been collected for long enough to determine whether droughts are increasing or decreasing over time. On a number of occasions, the Kenyan Government has declared a state of national disaster after severe droughts threatened livelihoods. In the year 2000, for instance, 4 million people were in need of food aid after Kenya was hit by its worst drought in 37 years.

10.3. Effects of Climate Change on AGBD

Climate variability has recently stimulated an issue of widespread and major concern where energies for mitigation and adaptation to changing environmental conditions have been strongly recommended by the IPCC (2007).Variability in climate has various implications on both crops and animals and may cause various effects.

Global warming is highest in tropical and subtropical regions where exposure of crops and animals to increasing temperatures is likely to occur. This may lead to reduced species diversity and lower agricultural yields as well as negative health and environmental effects. Global warming can also be responsible for sudden shifts in weather patterns manifested in phenomena such as the El Niño and La Niña. These changes have direct severe consequences on water availability and flooding threatening the livelihoods of people in the affected regions (Chakeredza et al., 2009). Increased soil evaporation, accelerated organic matter decomposition and increased pests and diseases' occurrence are some of the expected indirect effects of increased temperatures.

Animals are affected by climate change and global warming both in their distribution and behaviour. For example, birds lay eggs earlier in the year and migrate to their nesting grounds earlier than usual. Climate change is known to influence the physiology of domesticated animals thereby lowering productivity (Thornton et al., 2007).

10.4. Mitigation strategies against effects of climate change

Use of Indigenous knowledge systems: climate change adaptation based on indigenous knowledge and practices are imperative. The approach should involve community-based participatory learning and action focusing on the priorities, knowledge and capacities of local people (*Reid et al., 2009)*.

Adaptation of organisms to climate change: requires their exposure to the environment with due consideration of the wide agro-ecological variation of sites. Adaptation requires traditional breeding techniques for resistance to environmental stress (e.g., drought tolerance). *In-situ* conservation complemented with *ex-situ* gene banks is promising. Generally, AGBD conservation must become a basic component of adaptation strategies to climate change. National policy responses to climate change, with adequate attention to vulnerability and adaptation, and national adaptation programmes of action are necessary.

Interventions to climate change

Adapting to climate change usually involves a range of actions at three levels namely, ecosystem, agricultural system, and inter- and intra-specific diversity. Besides, innovations based on indigenous knowledge and new technologies (traditional crop varieties and animal species) and socio-cultural and political factors play an important role. Adapting to climate change by indigenous agricultural communities is based on:

a) Enhancement through a strategy of diversification (agro forestry, diverse crop and animal species and varieties) of the agricultural system for resilient local food systems.
b) Ecosystem protection and restoration to reduce vulnerability to extreme weather effects such as drought, flooding and landslides. Sustainable types of agriculture and land management can reduce the adverse impacts of climate change on fragile ecosystems and encourage

rehabilitation of degraded landscapes.

c) Enhancement through sustainable agricultural practices (e.g., low-input agriculture).

d) Protection of AGBD through programmes, such as promotion and cultivation of indigenous root and tuber crops, initiated and managed by local social groups.

e) Use of traditional knowledge systems combined with access to new knowledge. Local management systems of ecosystems, landscapes, agricultural systems and genetic resources are often harmonized with and adjusted to changing agro-climatic conditions.

10.5. Key Points

- Variability in climate has several implications on both crops and animals and may cause various effects.
- AGBD conservation is an important component of mitigation of climate change.
- Indigenous knowledge and practices contribute to conservation of AGBD and, consequently, reduce the effects of climate change.
- Adaptation of organisms to climate change requires their exposure to the environment and traditional breeding techniques for resistance to environmental stresses.
- *In-situ* conservation complemented with *ex-situ* gene banks is pertinent for AGBD.
- AGBD conservation must become a basic component of adaptation strategies to climate Change.
- National policy responses to climate change, with adequate attention to vulnerability \ and adaptation, and national adaptation programmes of action are necessary

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Exercise

Objective: To recognize the effects of climate change on AGBD and mitigation strategies against climate change in Kenya.

Time: 20 minutes

Method: Small group discussion for 15 minutes and 5 minutes presentation.

Materials: Flip charts and felt pens.

Questions:

1. Discuss and summarize the effects of climate change on AGBD in Kenya.
2. Discuss and summarize mitigation strategies against the effects of climate change on AGBD in Kenya.

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