

TRAINING MANUAL



**FOR SUSTAINABLE ECOLOGICAL AGRICULTURE
AND COMMUNITY DEVELOPMENT**

VERSION 2017

PREAMBLE

Training Manual for Sustainable Ecological Agriculture and Community Development– Edited version 2017

The harmonization and production of this manual is a joint activity of Participatory Ecological Land Use Management (PELUM- Kenya) in collaboration with:

- Sustainable Agriculture for Community Development (SACDEP) www.sacdepkenya.org
- Resources Oriented Development Initiatives (RODI-Kenya) www.rodikenya.org.
- Organic Agriculture Centre of Kenya (OACK). www.oack.or.ke.
- Institute for Culture and Ecology (ICE). www.icekenya.org.
- Community sustainable Development Programme (COSDEP). www.coskenya.com.
- Ministry of Agriculture
- Kenya Tea Development Agency (KTDA)

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INFORMATION ABOUT PELUM KENYA

Participatory Ecological Land Use Management (PELUM) Association is a membership organization in East and Southern Africa. The organization was started in 1995 and has grown from the initial 25 member organizations to 210 spread in 12 countries in East, Central and Southern Africa: Kenya, Uganda, Tanzania, Rwanda, Zambia, Zimbabwe, Malawi, Botswana, Lesotho, South Africa, Swaziland, and Ethiopia. Each country has its own member organizations referred to as the Country Working Group (CWG). The Associational regional activities are coordinated at the Regional Desk (RD), currently located in Lusaka, Zambia. All the PELUM Association network members promotes ecological land use management practices for improved livelihoods by the small scale farmers

PELUM Kenya is the Kenyan country chapter of the PELUM association and has a membership of 49 organizations in Kenya. PELUM Kenya network promotes people driven development towards sustainable land use and facilitates learning, networking, advocacy and lobbying for sustainable natural resource management. Its vision is for communities to be self-organized to make choices towards an improved quality of life that is socially, economically and ecologically sustainable. The Association is passionate about equity, people- driven development and integrity of creation, and strives for sustainable local community empowerment as well as food security and prosperity.

Its main target beneficiaries are the small scale farmers in the regions where PELUM Kenya is operational.

Vision: empowered and prosperous communities deriving their livelihoods from sustainable land use.

Mission: -To promote participatory ecological land use and management practices for improved livelihoods among small holder farmers in Kenya

PELUM Kenya is based in Thika, Kenya. It has programmes in Research and Information Management, Capacity Enhancement, Management and Development and Campaign Advocacy and Lobbying. Its goal is to enhance the capacities of local communities and empower them to manage and sustain the natural resources around them. PELUM Kenya pays particular attention to Agricultural and Ecological Biodiversity.

NETWORKING AND COLLABORATION

PELUM Kenya believes in the spirit of networking and collaboration to increase the impact of its work to its grass-root beneficiaries: the communities and small holder farmers. The Network has continuously increased its collaboration efforts among its members; leading to increased adoption of ecological land use best practices by farmers and communities at the grass root level and increase the visibility of PELUM Kenya in the country.

PILOT PROJECT – FOOD SECURITY AND LIVELIHOOD IMPROVEMNET (FOSELI)

To strengthen networking and collaboration among its members, five of the PELUM members in the central zone and working with small holder tea farmers: Sustainable Agriculture Community Development Programme (SACDEP-Kenya), Institute for Culture and Ecology (ICE), Organic Agriculture Centre of Kenya (OACK), Resources Oriented Development Initiatives (RODI-Kenya) and Community Sustainable Development Empowerment Programme (COSDEP), designed a joint project to address some issues experienced by small holder tea farmers. The issues include: food and nutrition insecurity, low income, poor financial management among others

FOSELI project aims at enabling tea farmers from Central region of Kenya to acquire skills that will boost agro-productivity by emphasizing on building long-term sustainable water shed management, sustainable cropping practices and increased incomes.

The project is being implemented in partnership with Ministry of Agriculture and Kenya Tea Development Agency.

USER'S GUIDE TO THE TRAINING MANUAL

About the Manual

Sustainable Ecological Agriculture practices are unique and through their proper application in farming systems, it's possible for farmers to realize and contribute to enhanced food and nutrition security, environmental health and sustainable economy

This manual provides an introduction to the various sustainable ecological agriculture practices and their application in small holder farming. Additionally, the manual is designed to assist trainers to effectively understand various technologies as applied in sustainable ecological agriculture and to effectively pass on the information and skills to farmers

The intended users include: agricultural extension officers and trainers both in the NGO sector, the Kenya Government and its agencies. It provides a framework, relevant information and tools to build on sustainable development according to specific needs of farmers.

This training manual edition is not intended to function as the comprehensive source of information on Sustainable Ecological

Agriculture; rather, it is designed to be used as a guide tool to assist in the decision-making process for trainers.

Therefore, trainers should not use this training manual as their only reference and source of information on Sustainable Ecological Agriculture and Community Development.

Manual format and intended objectives

This manual is divided into specific chapters based on the training course units related to Sustainable Ecological Agriculture and community Development

This training module is intended to provide the knowledge and competencies to trainers in sustainable ecological agriculture practices to effectively train farmers.

It is expected that by the end of training program, farmers will gain knowledge and practical skills in sustainable ecological agriculture and apply/practice the skills to enhance food production, nutrition security and livelihood improvement.

CHAPTER 1: INTRODUCTION TO SUSTAINABLE ECOLOGICAL AGRICULTURE

1. Introduction and background to Sustainable Ecological Agriculture

Increasingly, agricultural productivity, food, nutrition and income security remains key priorities for the Kenyan Government as detailed under the economic pillar of vision 2030. However, farmers continue to experience various unprecedented limitations to agricultural production. Some of these include:

- ▶ Low literacy levels and in adequate information on sustainable farming practices among farmers pose another challenge in agricultural production. Majority of small scale farmers have little understanding on best agricultural practices. Such as in fertility management, use yielding varieties, pest and disease management practices.
- ▶ Declining soil fertility –due to poor soil management practices on cultivated lands, the extent of soil degradation is increasing in many parts of Kenya. Even in areas where the soil is not completely degraded, the consistent decline in soil fertility leads to low production
- ▶ Decline in arable land –As the population continues to grow and the arable land continues to decrease, shortage of land and land fragmentation result in increasing land use intensity and land conflicts in many parts of the country.
- ▶ Effects of climate change – Most agriculture in Kenya is rain-fed and farmers heavily rely on the rainfall patterns to plan their production activities. With the increasing unpredictability of rains in terms of amount and timing, crop failures and famine are increasingly becoming common. Un-reliable rainfall and water shortage are among the main causes for low crop yields.

This can also be attributed to the broader climate change factors, but also to the continued environmental degradation and pollution.

- ▶ Limited access to safe and sustainable inputs – Quality seed, fertilizers, sustainable pest and disease management agents and tools are not accessible to many small scale farmers. In addition, most farmers cannot afford and access inputs in the nearby centres; this is especially the case for organic inputs such as organic pesticides, biological agents and organic fertilizers.
- ▶ Limited access to reliable markets– Most farmers understand the agricultural value chain and market dynamics. Equally they do not have the knowledge and experience in adding value to their farm products. They also suffer low product quality and lack of consistency in production.

These challenges have highly contributed to continued decline in food crop yields leading to the widespread food insecurity, hunger, poverty and malnutrition in Kenya

With the increasing demand to address the above challenges in Kenya and beyond, alternative approaches to conventional agriculture have taken a key role in promoting sustainable development.

Sustainable development is the form of economic growth which satisfies society's needs in terms of well-being in the short, medium and long. It relies on the assumption that development must meet the needs of the present without having to put in danger the future generations. Thus, development can generate prosperity if it regenerates the resources and protects the environment. Development is sustainable only if the stock of resources per capita remains constant or increases with the passage of time.

This alternative perspective to development has challenged conventional agriculture's core values of economic growth and the domination of nature.

Despite great progress in agricultural productivity in the past half-century, with crop and livestock productivity strongly driven by increased use of fertilizers, irrigation water, agricultural machinery, pesticides and land, it would be over-optimistic to assume that these relationships will remain linear in the future.

The problems of modern high input agriculture are presently causing major concern in the agricultural sector. The fundamental problem is undermining of the energy efficient self-sustaining character of an agro ecological system. In addition, the ecological and sociological effects and problems of contemporary conventional agriculture are in the news almost daily.

Concerns about sustainability in agricultural systems focus on the need to develop technologies and practices that do not have adverse effects on the environmental and human health, are accessible to and effective for farmers' application, and lead to improvement in food productivity, nutrition security, health and income

These concerns have prompted the introduction of ecological farming systems that promote sustainable land use, human and environmental health as well as economic growth. The manual will mainly focus on a more effective alternative system called Sustainable Ecological Agriculture.

Ecological agriculture refers to a self-sustaining agro ecosystem and energy management of natural ecosystems. Man and his activities are integrated in the system; the production is characterized by a holistic view of plant and animal production.

Ecological Agriculture provides a holistic understanding of how agro ecosystems work. It emphasizes the interrelationships among soils, plants, insects, animals, humans and other components of agro ecosystems. Ecological agriculture includes all methods, including organic, which regenerate ecosystem services like: prevention of soil erosion, water infiltration and

retention, carbon sequestration in the form of humus, and increased biodiversity.

Sustainability rests on the principle that ecological agriculture meets the needs of the present without compromising the ability of future generations to meet their own needs.

Ecological agriculture is truly sustainable – it can regenerate and re-fertilize the degraded and damaged agricultural soils that cover most of the world, and will allow us to continue producing food on that land indefinitely. Conventional agriculture degrades and depletes the soil, and so cannot continue to feed us, and the “progress” made in agriculture in the last decades has come at an enormous environmental and social cost

Sustainable Ecological Agriculture should meet the following elements

- ▶ It must be self-sustaining. It is managed to reduce losses to a minimum, and all by-products are recycled. Decomposers and nitrogen fixers are encouraged. Fertility is maintained by techniques such as crop rotations, agro forestry, composting etc
- ▶ It must be diversified in order to be self sustaining, also to increase stability and maximize biomass production. The ratio of animals (including humans) to plants must therefore be appropriate.
- ▶ The net yield per unit area must be maximized. Appropriate tillage and soil fertility enhancing techniques are outlined in the manual.
- ▶ It must be economically viable. This alternative farming system is aimed to operate at a real profit.
- ▶ It must be aesthetically, socially and ethically acceptable

In sustainable ecological agriculture, several general principles can be applied to help farmers select appropriate management practices:

- Selection of species and varieties that are well suited to the site and to conditions on the farm

- Diversification of crops (including livestock) and cultural practices to enhance the biological and economic stability of the farm
- Management of the soil to enhance and protect soil quality
- Efficient and humane use of inputs
- Consideration of farmers' goals and lifestyle choices.

Sustainable ecological agricultural production is part of a larger chain, including food production, food processing, distribution and retail sectors, and ultimately, the consumer. Every link in this chain should play a role in maintaining sustainable agricultural systems such as:

- Environmental protection- the environment can provide to agricultural systems all the resources they need to produce fresh, delicious and quality food for human consumption.
- Animal welfare- modern consumers expect that animals raised on farms are entitled to have the same things that we have– as human beings: good food, good living conditions and medical care.
- Consumer confidence- Consumers represent the final link in the chain of distribution of agricultural products, and thus should be given the most attention in order to offer them high quality products that are safe for human consumption.

2. Scope of Sustainable Ecological Agriculture

Sustainable Ecological Agriculture production practices involve a variety of approaches aimed at promoting sustainable agro-ecosystems. Such approaches include: sustainable agriculture, organic farming, biodynamic farming, conservational agriculture, permaculture and bio-intensive agriculture

• Sustainable agriculture

Sustainable agriculture means the successful management of resources to satisfy human needs today without endangering the ability of future

generations to satisfy their needs. In this context, sustainable agriculture is a production system that attempts to provide long-term sustained yields through the use of ecologically sound management technologies such as crop diversification, recirculation of plant nutrients and biological pest control.

Sustainable agriculture can be understood as an ecosystem approach to agriculture. Not only does sustainable agriculture address many environmental and social concerns, but it offers innovative and economically viable opportunities for growers, laborers, consumers, policymakers and many others in the entire food system.

Sustainable agriculture is thus:

1. Ecologically sound: the quality of natural resources within an environmentally sound system is maintained or enhanced.
2. Economically viable: farmers can produce enough food for self-sufficiency and obtain an adequate income.
3. Socially just: resources and power are distributed in such a way that the rights to land use, adequate capital, market opportunities and technical assistance are assured.
4. Humane: all forms of life (plant, animal, human) are respected.
5. Adaptable: rural communities are capable of adjusting to constantly changing farming conditions.

Practitioners of sustainable agriculture seek to integrate three main objectives into their work: a healthy environment, economic profitability, and social and economic equity. Every person involved in the food system i.e-growers, food processors, distributors, retailers, consumers, and waste managers can play a role in ensuring a sustainable agricultural system.

• Organic Agriculture

Organic Agriculture can be defined as an approach to agriculture where the aim is to create integrated, humane, environmentally and economically

sustainable agricultural production systems. Maximum reliance is placed on locally or farm-derived renewable resources and the management of self-regulating ecological and biological processes and interactions in order to provide acceptable levels of crop, livestock and human nutrition, protection from pests and diseases, and an appropriate return to the human and other resources employed. Reliance on external inputs, whether chemical or organic, is reduced as far as possible

The term 'organic' is best thought of as referring to the concept of the farm as an organism, in which all the component parts - the soil minerals, organic matter, micro-organisms, insects, plants, animals and humans - interact to create a coherent and stable whole.

Organic agriculture is based on a number of objectives and principles, as well as on good practices designed to minimize human impact on the environment, ensuring at the same time that the agricultural system operates as naturally as possible.

Organic Agriculture can be defined by a commitment to the principles of health, ecology, fairness and care.

- The principle of health refers to the idea that all organic farming should enhance and sustain everything involved in the process, from the soil all the way to the people who consume the food.
- The principle of ecology says that the practices of organic farms should work with existent ecological cycles and systems.
- The principle of fairness says that organic agriculture should be practiced in ways that are fair to the environment and to the opportunities of those in the farm's community.
- The principle of care says that organic agriculture should always be managed in a responsible manner that protects the health of both people and the environment.

The specific practices of organic agriculture include:

- Crop rotation as a prerequisite for the efficient use of resources;
- Very strict limits on the use of synthetic chemical pesticides and fertilizers, antibiotics, food additives and other complementary materials used for processing agricultural products;
- Prohibiting the use of genetically modified organisms;
- Using the existing on the spot resources, such as in the case of use of manure from animal feed and farm products;
- Choosing of plant and animal species that are resistant to diseases and pests, adapted to the local conditions;
- Animal husbandry in freedom and open shelters and feeding them organic feed with the use of farming practices adapted to each breed in hand.

Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.

The objective of sustainability lies at the heart of organic farming and is one of the major factors determining the acceptability or otherwise of specific production practices. The term 'sustainable' is used in its widest sense, to encompass not just conservation of nonrenewable resources (soil, energy, minerals) but also issues of environmental, economic and social sustainability

- **Biodynamic agriculture**

Bio-dynamics is a holistic, ecological, and ethical approach to farming, gardening, food and nutrition. Biodynamic agriculture has been practiced for nearly a century, on every continent on Earth. Biodynamic principles and practices are based on the spiritual insights and practical suggestions of Dr. Rudolf Steiner, and have been developed through the collaboration

of many farmers and researchers since the early 1920's.

Biodynamic agriculture principles have a greater focus on astrological cycles and the idea of the farm as a single 'organism'.

- A biodynamic farm is conceived as a single entity that can be viewed as an organism in and of itself.
- Biodynamic farms should remain as enclosed from their surrounding ecosystems as is possible.
- Biodynamic farms are structured around lunar and astrological cycles that are said to affect the biological systems.
- Biodynamic farms are built to integrate all the living organisms within the system, including plants, livestock and farmers.
- The soil is seen as the central component of all biodynamic farms.

- **Conservation agriculture**

Conservation Agriculture (CA), also known as a 'no-till' farming system, is an effective solution to stopping agricultural land degradation, for rehabilitation, and for sustainable crop production intensification. Conservation agriculture has the following three core inter-linked principles (Friedrich et al., 2009):

- No or minimum mechanical soil disturbance and seeding or planting directly into undisturbed or untilled soil, in order to maintain or improve soil organic matter content, soil structure and overall soil health.
- Enhancing and maintaining organic mulch cover on the soil surface, using crops, cover crops or crop residues. This protects the soil surface, conserves water and nutrients, promotes soil biological activity and contributes to integrated weed and pest management.
- Diversification of species– both annuals and perennials - in associations, sequences and rotations that can include trees, shrubs, pastures and crops, all contributing to

enhanced crop and livestock nutrition and improved system resilience.

- **Bio-intensive agriculture**

Bio-intensive agriculture is an organic agricultural system that focuses on achieving maximum yields from a minimum area of land, while simultaneously increasing biodiversity and sustaining the fertility of the soil.

The goal of this approach is long term sustainability on a closed system basis. It is particularly effective for backyard gardeners and smallholder farmers in developing countries, and also has been used successfully on small-scale commercial farms.

John Jeavons and Ecology Action have refined a production system that makes it possible for one person to grow all of his or her family's food using truly sustainable methods that maintain the fertility of the soil without relying on nonrenewable resources like petrochemicals or imported organic matter.

- **Permaculture**

Permaculture is a contraction of "permanent agriculture,". The word "permaculture" was coined by Australian Bill Mollison in the late 1970s. Permaculture is one of the many alternative agriculture systems described as sustainable. It is "unique in its emphasis on design and focuses on the location of each element in a landscape and the evolution of landscape over time.

The goal of permaculture is to produce an efficient, low-maintenance integration of plants, animals, people and structure applied at the scale of a home garden, all the way through to a large farm.

3. Principles and practices of sustainable ecological agriculture

Ecological principles provide a good framework for sustainable management. Natural eco systems are characterized by the following principles:

- **Efficiency.** Efficient energy flows are characteristic of natural systems. The sun's energy captured by green plants is used by many organisms, as fungi and bacteria decompose organic residues and are then fed upon by other organisms, which are themselves fed upon by others higher up the food web.
- **Diversity.** High biological diversity, both above ground and in the soil, characterizes many natural ecosystems in temperate and tropical regions. It provides nutrients to plants, checks on disease outbreaks, etc. For example, competition for resources and specific antagonisms (such as antibiotic production) from the multitude of soil organisms usually keep soil-borne plant diseases from severely damaging a natural grassland or forest.
- **Self-sufficiency.** A consequence of efficiency and diversity in natural terrestrial ecosystems is that they become self-sufficient—requiring only inputs of sunlight and rainfall.
- **Self-regulation.** Because of the great diversity of organisms, outbreaks (or huge population increases) of diseases or insects that severely damage plants or animals are uncommon. In addition, plants have a number of defense mechanisms that help protect them from attack.
- **Resiliency.** Disturbances, such as climate extremes, occur in all ecosystems—natural or not. The stronger ones are more resistant to disturbances and are able to bounce back more quickly.

Like natural ecosystems, agro-ecosystems are characterized by nutrient flows and cycles, energy flows, and the interactions of living organisms with each other and the physical environment. However, agro-ecosystems differ from natural ecosystems in two key ways:

- We expect them to export particular biological goods for our use.
- we deliberately manipulate them to get them to produce those goods in abundance

Sustainable ecological agriculture seeks to take advantage of ecosystem processes by designing an agricultural system that works with them rather than against them to achieve its production goals.

New approaches are needed that will integrate biological and ecological processes into food production, minimize the use of those non-renewable inputs that cause harm to the environment or to the health of farmers and consumers, make productive use of the knowledge and skills of farmers, so substituting human capital for costly external inputs, and make productive use of people's collective capacities to work together to solve common agricultural and natural resource problems, such as for pest, watershed, irrigation, forest and credit management.

The key principles for sustainability in an agro-ecological system are to:

- i. Integrate biological and ecological processes such as nutrient cycling, nitrogen fixation, soil regeneration, allelopathy, competition, predation and parasitism into food production processes
- ii. Minimize the use of those non-renewable inputs that cause harm to the environment or to the health of farmers and consumers,
- iii. Make productive use of the knowledge and skills of farmers, thus improving their self-reliance and substituting human capital for costly external inputs, and
- iv. Make productive use of people's collective capacities to work together to solve common agricultural and natural resource problems, such as for pest, watershed, irrigation, forest and credit management.

There are several types of resource-conserving technologies and practices that can be used to improve and sustain agro-ecosystems. These are:

- **Integrated Pest Management (IPM)**, which uses ecosystem resilience and diversity for pest, disease and weed control, and seeks only to use pesticides when other options are ineffective. IPM manages pests by combining biological, cultural, physical and

chemical tools in a way that minimizes economic, health and environmental risks.

- Integrated nutrient management, which seeks both to balance the need to fix nitrogen within farm systems with the need to import inorganic and organic sources of nutrients and to reduce nutrient losses through erosion control. Central management of nitrogen and other plant nutrients improves the soil and protects the environment. Increased use of on-farm nutrient sources, such as manure and leguminous cover crops, reduces the need to buy fertilizer
- Soil conservation- Many soil conservation methods, including strip cropping, reduce tillage and conservation tillage help prevent loss of soil due to wind and water erosion.
- Water conservation including water shed and wet land management.- Water conservation and protection are important parts of sustainable ecological agriculture. Many practices improve quality of drinking and surface water, as well as to protect wetlands. Wetlands play a key role in filtering nutrients and pesticides, in addition to providing wildlife habitat.
- Crop/Landscape diversity- Growing a greater variety of crops on a farm reduces risks from extremes in weather, market conditions or crop pests. It also contributes to soil conservation, wildlife habitat and increased populations of beneficial insects. Growing plants such as rye or clover in the off season after harvesting a grain or vegetable crop provides many benefits, including weed control, erosion control, and improved soil nutrients and soil quality.
- Agro forestry, which incorporates multifunctional trees into agricultural systems and collective management of

nearby forest resources. Agro forestry covers a range of tree uses on farms, including interplanting trees with crops or pasture, better managing woodlots, and using trees and shrubs along streams as riparian buffer strips.

- Livestock integration into farming systems, such as dairy cattle, dairy goats, pigs and poultry.
- Marketing- Farmers often find that improved marketing provides a key way to enhance profitability. Direct marketing of agricultural goods to consumers, such as farmers' markets, roadside stands and community-supported agriculture, is becoming much more common.

All these practices contribute to long-term farm profitability, environmental stewardship and quality of life for small scale farmers.

4. Transition from conventional to sustainable ecological agriculture

Making a transition to sustainable ecological agriculture is a process. For small scale farmers, the transition to sustainable ecological agriculture normally requires a series of small, realistic steps to manage the environment, soil, crops and animals.

Family economics and personal goals influence how fast or how far farmers can go in the transition. It is important to realize that each small decision can make a difference and contribute to advancing the entire agro ecological system. The key to transition is the will to take the next step.

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CHAPTER 2: FOOD AND NUTRITION

1. Introduction and overview of food and nutrition

Food is defined as any substance containing nutrients (such as carbohydrates, vitamins, proteins, and fats) that can be ingested by a living organism and metabolized into energy and body tissue. In essence, food stimulates growth, helps us to stay alive and produces energy.

Food is one of the basic necessities of life. It is more than other basic needs shelter and clothing. The food that we eat is composed of small units that provide nourishment to the body. These are required in varying amounts in different parts of the body for performing specific functions. This means that good nutrition is essential for good health. However, if our diet provides the important units in incorrect amounts, either very less or in excess of what is required, it results in an imbalance of nutrients in your body. The condition is responsible for various deficiency diseases and slow or no growth of the body

Food, nutrition, health and nutritional status are connected with life. So, we must have proper clarity of these aspects of healthy life. Food is that which nourishes our body and keeps us healthy. It can be defined anything eaten or drunk, when swallowed, digested and assimilated in the body, keeps it well. In short, food is the raw material from which our body is made. When we take any kind of food, we ensure good health which could be evident in our physical appearances, work efficiency and emotional well-being.

The term 'nutrition' broadly covers all processes through which we obtain, prepare and eat food. It further describes what different foods are made of (i.e. nutrients) and the processes through which our bodies make use of the nutrients to enable us to perform daily activities such as work. Apart from focusing on what we should eat, nutrition is also concerned with promoting aspects of personal and environmental hygiene and sanitation, promoting health seeking behaviours and

providing care for all household members so that they are healthy.

Nutrients are the chemical substances found in food that are required by the body in adequate amount to grow, reproduce and lead a normal healthy life. These are proteins, carbohydrates, fats, vitamins, minerals and water.

Good or Adequate nutrition implies that the essential nutrients are present in correct amount and proportion. It also indicates the manner of nutrient utilization, so that the highest level of physical and mental health is achieved throughout life time.

Malnutrition means undesirable kind of nutrition, leading to ill health. It results from lack, excess or imbalance of nutrients in the diet. It comprises of two types under nutrition and over nutrition. Under nutrition refers to inadequate/insufficient supply of essential nutrients, whereas in over nutrition, there is excess supply of one or more nutrients, which creates stresses in the body functions.

Food security is achieved, when each person has (physical and economic) access at all times to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. This requires a nutritionally diverse diet.

In other words, to be 'food secure' at individual, household, village, or community level, food should be:

- Available: refers to the physical presence of food, be it from own production or from the market or shops
- Accessible: refers to households and all individuals within those households having sufficient resources such as money, labour, time and knowledge to obtain appropriate foods for a nutritious diet

- Utilizable: Individuals should be able to eat and absorb in their bodies the available and accessible food. There should be no diseases or ailments like diarrhoea, malaria, worm infestation that limit individuals from benefiting from the eaten food
- Sustainable: Individuals should feel confident that they will have enough food to feed their family tomorrow, the next week, month and year. Food should therefore be available, accessible and utilizable at all times.

Nutrient security is more than food security. Individuals, households and communities can only attain good health and nutrition if the three conditions of nutrient security; food security, adequate care, and adequate prevention and control of diseases are achieved.

Nutrition security is said to exist when food security is combined with education, a sanitary environment, adequate health services and proper care and feeding practices to ensure a healthy life for all household members (UNSCN 6th Report on the World Nutrition Situation)

In order to achieve food and nutrition security among tea farmers, the underlying factors holding individuals back from accessing and utilising food, providing care for household members and seeking treatment for all ailments would need to be addressed.

2. Key nutrients of concern in food and nutrition

Nutrients are the chemical substances found in food. They are extracted from food as it passes through our digestive system and are used by the body to perform its functions. Nutrients contained in food are needed in the right amounts and combinations for the body to function properly. There are six basic nutrients required by human body for a healthy life. These are: Carbohydrates, Vitamins, Proteins, Minerals, Fats and Water

These nutrients are also divided into two broad categories:

Macronutrients are required by the body in large amounts; they include carbohydrates, proteins and fat.

Micronutrients are required in relatively smaller amounts by the body; they include vitamins and minerals.

The body needs a mixture of both macro and micro nutrients for it to be healthy and function optimally. We access these nutrients through eating food.

3. Food classification and categories

Food can be classified based on the key nutrients it supplies to the body. According to this classification there are four major categories:

- Energy giving foods
- Body building foods
- Protective foods
- Water (essential for nutrient absorption and the human body to function properly).

a. Energy giving foods

Most nutritionists agree that 55 to 65% of our diet should be carbohydrates. Energy giving foods provide the energy needed by our bodies to:

- Perform activities such as walking, digging, working
- Maintain normal physiological processes such as breathing and all other processes within our bodies

Energy giving foods are mainly rich in carbohydrates or fats. We obtain carbohydrates through eating plant-based foods.

The main examples of carbohydrate containing foods include: millet, Irish potatoes, sweet potatoes, cassava, ugali (made from maize or other flour), sorghum, yams, rice, plantain (matooke) and bread.

Fats and oils are usually solid, semi-solids or liquid depending on their chemical composition and environmental temperatures. Examples of fats and oils commonly consumed in our diets include

liquid oils (sunflower oil, vegetable oils oil), ghee, and animal fat. Fats and oils also add flavour and taste to food. They further insulate the body, cushion vital organs and are essential for the absorption and utilization of fat-soluble vitamins A, D, E and K. Thus, a very low consumption of fats and oils may lead to a deficiency of these vitamins predisposing our bodies to diseases and/or symptoms associated with a lack of these vitamins

b. Body building foods

These are food rich in the food nutrients called proteins. They are essential for growth, boosting body immunity against infections and diseases, the formation of all tissues, including muscles, bones, teeth, skin and nails and for wound repair.

It is recommended that 15 to 20% of the diet come from protein. Proteins come from two major sources:

- Animal-based foods and related products: fish, meat, poultry, eggs, milk and milk products including yoghurt and fermented milk • Others include edible insects



- Plant-based foods and related products: mainly beans (including soy beans) and peas



Animal-based foods provide a richer source of proteins that are more easily utilised by the body than those supplied by plant-based foods.

We can increase household intake of animal-based proteins by integrating certain animals and birds in our farming system. The birds (hens, ducks) can be eaten but also lay eggs, which are a rich source of proteins. Animals like rabbits are also relatively easy to rear: they do not require much space to be kept, are not too demanding in as far as feeding is concerned and have high multiplication rates.

We have different protein requirements at different ages:

- Children require more protein-rich foods than adults because they are growing.
- Pregnant women should also eat plenty of protein-rich foods because they need to feed themselves as well as their growing baby. The same is true for lactating / breastfeeding mothers whose bodies need to be able to produce breast milk.

c. Protective foods

These include vegetables and fruits. These foods are rich in vitamins and minerals which are required by the body for physiological functions such as the strengthening of the immune/defense system and to prevent conditions such as anaemia (resulting from iron deficiency), night blindness (resulting from Vitamin A deficiency), goitre (resulting from iodine deficiency) and rickets (resulting from a lack of Vitamin D and calcium).

Vegetables and fruits are a major source of vitamins and minerals which are required by our brain, eyes, muscles, bones, blood, glands, etc to perform all the functions for which they are designed

Some vitamins and minerals are also essential for the production of energy by the body and maintaining water balance in the body.

- Vegetables are a rich source of several vitamins and minerals. In addition, vegetables add taste, flavour and colour to our meals. Common vegetables include: amaranth, spinach, kales pumpkin leaves, cowpea leaves, carrots, cassava leaves, green pepper, etc



- Fruits – Farmers should grow a variety of fruits including: avocados, mangoes, pawpaw, pumpkin, passion fruit, pineapple, jackfruit, oranges, lemons and other citrus fruits. The deep yellow or orange coloured fruits are richer in vitamins, particularly vitamin A.



Key vitamins and minerals for children and pregnant/breastfeeding women include:

- Iron: Iron deficiency is a major cause of anaemia and impairs the child's/baby's cognitive and physical development
- Iodine: Iodine deficiency is the greatest single cause of mental retardation and brain damage

- Vitamin A: Vitamin A deficiency causes early childhood blindness and increases the severity of infections and anaemia, in both children and pregnant/breastfeeding women.
- Zinc: Zinc deficiency affects children's health and physical growth; it is also essential for mothers during pregnancy

Examples of vitamins and minerals, their functions and food sources

Nutrient	Function	Food sources
Vitamin A	<ul style="list-style-type: none"> • Strengthens our immunity which helps us fight off infections • Essential for proper functioning of eyes, that is it improves vision in dim light • Keeps the skin and the linings of some parts of the body, such as the nose, mouth, throat, eyes, ears, lungs and other organs healthy 	<ul style="list-style-type: none"> • Dark green leafy vegetables such as spinach, broccoli • Dairy Milk and its products • Yellow or orange fruits and vegetables such as pumpkin, carrot, papaya, mango, etc • liver, fish, kidney eggs, fortified margarine
Vitamin D	<ul style="list-style-type: none"> • Helps the body in proper absorption and utilization of calcium and phosphorus • Necessary for formation and maintenance of strong, healthy teeth and bones 	<ul style="list-style-type: none"> • Exposure of skin to Sun light • Eggs, liver, fish liver oils, fortified margarine • Milk and butter
Vitamin E	<ul style="list-style-type: none"> • Helps maintain cell structure by protecting cell membranes 	<ul style="list-style-type: none"> • Cereals and pulses: Soya, groundnuts, wholegrain cereals • fortified margarine, vegetable oils, eggs, peanut butter, tomatoes
Vitamin K	<ul style="list-style-type: none"> • Helps with blood clotting 	<ul style="list-style-type: none"> • Vegetables such as spinach, lettuce, cauliflower, cabbage and broccoli. • fish, liver, meat, eggs
Vitamin B complex	<ul style="list-style-type: none"> • Necessary for utilization of carbohydrates in the body • Help the body release energy from food • Helps body organs to function normally • Needed for formation of red blood cell • Helps in digestion and improves appetite. • Keep the skin, eyes and the nervous system healthy 	<ul style="list-style-type: none"> • Whole grain cereals and pulses: Millet, sorghum, beans, peas, • eggs, liver, meat, milk, • fresh fruits, • green leafy vegetables,
Vitamin C	<ul style="list-style-type: none"> • Helps with wound healing Strengthens our immunity which helps us fight off 	<ul style="list-style-type: none"> • Citrus fruits such as oranges, lemons and tangerines,

	infections	<ul style="list-style-type: none"> • red and green peppers, tomatoes, broccoli, potatoes • Green leafy vegetables, • Sprouted pulses such as grams
Folic acid	<ul style="list-style-type: none"> • Helps form healthy red blood cells • Helps reduce the risk of central nervous system defects. 	<ul style="list-style-type: none"> • Leafy green vegetables such as spinach, broccoli, and lettuce, • liver, beans, peas, • fruits such as oranges, bananas, avocados and melons
Iron	<ul style="list-style-type: none"> • Helps make red blood cells, which carry oxygen around the body 	<ul style="list-style-type: none"> • Liver, meat, beans, millet, sorghum, ground nuts, eggs, • most dark green leafy vegetables such as amaranth and parsley
Calcium	<ul style="list-style-type: none"> • Helps build strong bones and teeth • Helps muscles and nerves function normally • Helps to ensure blood clots normally 	<ul style="list-style-type: none"> • Milk, cheese and other dairy foods, • green leafy vegetables, such as cabbage, grain amaranth and okra
Iodine	<ul style="list-style-type: none"> • Helps to regulate the thyroid gland (in the neck) which controls the development of the body, including the brain, and regulates physiological processes (or metabolism). 	<ul style="list-style-type: none"> • Iodized salt, sea food

d. Water

Water is the major constituent of our body. It forms about two-thirds of the body weight. We can do without food more readily than water. It is present in all the cells, being a vital part of all living tissues. It surrounds tissues and organs, and gives protection from shock.

Normally, we need to drink 6-8 glasses of water everyday. Other forms in which we can receive water are milk, juice, etc

Water is essential for the human body to function properly. As the body cannot store water, it requires fresh supplies of safe, clean water every day.

The amount a person needs to drink depends on a variety of factors such as environmental temperature and activity level. E.g. if you work hard in hot weather you may need to drink more.

The body requires water for many reasons:

- Water helps in digestion, absorption and transportation of nutrients in the body.
- It helps to excrete unwanted materials in the form of urine and maintains body temperature through perspiration.
- To make blood, saliva, tears and sweat
- To keep the mouth and lungs moist, and to keep the skin moist and cool
- To produce breast milk, which is also a source of water for breastfeeding children.

4. Planning for a healthy/ balanced diet

A 'healthy/balanced diet' is a diet that is able to provide all the recommended (adequate) amounts of nutrients in the right amounts and quality for the body to perform all its physical and physiological activities depending on one's age, sex and physical activity level.

A healthy diet provides the body with essential nutrition: fluid, adequate essential amino acids from protein, essential fatty acids, vitamins, minerals, and adequate calories.

This implies that all the main food types (carbohydrates, fats, proteins, vitamins, minerals, and water) are eaten in correct proportions throughout the daily life of an individual. Balanced diets benefit individuals, families, communities and the nation at large.

Unfortunately, today's world has been adapted to a system of consumption of foods which has several adverse effects on human health. Lifestyle changes has compelled us so much that one has so little time to really think what we are eating is a healthy diet.

In many cases, the choice of food a person takes is influenced by:

- Personal preference: how the food looks, feels, smells and tastes
- Cultural traditions or ethnic backgrounds
- Peers influence
- Media Messages (ads)
- Convenient and available food – eg based on seasons

It is especially important for the following categories of people to have a balanced diet:

Pregnant/Expectant women

- Their food intake will need to support themselves as well as their growing foetus ,therefore they need more nutrients than non-pregnant women

- The foetus/baby (inside the woman's womb) needs a wide variety of nutrients in order to grow well and be physically and mentally healthy, e.g. folic acid and iron

Breastfeeding/lactating women

- Lactating mothers need enough nutrients so that they have enough energy to go about their daily lives as well as produce breast milk
- Maternal nutrition has only a minor effect on the composition and quantity of breast milk produced. Unless a mother is severely malnourished, her milk will be fine
- Mothers whose diets are poor deplete their own energy levels, and may become anemic, but their bodies will continue to produce the milk their baby needs by pulling from the mother's energy stores (at her expense but not her baby's expense)

Babies (up to 6 months)

- They need to be breastfed. Breast milk contains all the nutrients a baby needs Children
- They are growing and developing (physically and mentally) and therefore have extra nutritional needs to be able to do so
- They are meant to gain body weight and height. If children are under-nourished they risk 'wasting' or being 'stunted'
- The first 1,000 days in a child's life (starts at conception and until 2 years of age) are crucial. Any damage to their growth (physically and mentally) in these 1,000 days through a lack of nutrients is irreversible
- A child with an adequate diet has a stronger immune system (than an undernourished child) and this helps him/her fight off illnesses

People with chronic (long-term) illnesses (e.g. HIV/AIDS, diabetes, Cancer, etc)

- They will better respond to treatment
- Adequate nutrition will affect the immune system and help them fight off other diseases

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Generally speaking, in order to maintain/attain a balanced diet, we should eat:

- Starchy foods, such as millet, rice, potatoes, cassava, matooke. Starchy foods should make up around one third of everything we eat
- Fruits and vegetables. They are a vital source of vitamins and minerals. We should try to eat a variety of fruit and vegetables each day, ideally 5 portions in total (e.g. 3 types of vegetables and 2 fruits)
- Meat, fish, eggs, beans, nuts and seeds.- These foods are all good sources of protein, vitamins and minerals
- Milk and dairy foods: Milk and dairy foods such as fortified yoghurt are good sources of protein, vitamins A, D, and B group vitamins and the mineral calcium

- Moderate amount of food high in fat and/or sugar. Fats and sugar are both sources of energy for the body. In addition, fats help transport fat soluble vitamins. Health recommendations stipulate a modest intake of fat and sugar. An excess of these foods can lead to being overweight or obese as well as the development of other diseases like diabetes and heart disease.

We need a **balanced diet** to stay healthy. Children also need it to grow well, both physically and mentally. Eating a diverse diet means eating many different foods each day so that we consume lots of different nutrients. These nutrients keep us healthy in different ways: e.g. iron helps the body make red bloods cells (which carry around oxygen and therefore give us energy), vitamin C helps fight off illnesses and protein is the body's primary building block for muscles, bones, skin and hair. Most foods provide more than one nutrient. We need to eat all of the following in the right amounts:

TYPES OF NUTRIENTS	FOODS THAT CONTAIN THESE NUTRIENTS	BENEFITS OF THESE NUTRIENTS
Proteins	Animal-based: fish, meat (includes poultry), eggs, milk, yoghurt, grasshoppers and white ants Plant-based: beans (including soy beans) peas, nuts, seeds	Build and repair our bodies
Carbohydrates	Millet, Irish potatoes, sweet potatoes, cassava, Ugali, sorghum, yams, rice, plantain (matooke) and bread	Give us energy
Fats	Sunflower oil, vegetable oil ghee, butter etc	Give us energy
Vitamins & Minerals	Fruits: mango, orange, pineapple, avocado, passion etc vegetables: amaranth (dodo), spinach, Kale, pumpkin leaves, cowpea leaves, carrots, cassava leaves, green pepper, green beans, tomato, sweet potato	Protect against illness Help produce energy Maintain water balance
	CLEAN WATER and other drinks	Hydration

N.B- Nutritious diets do not have to be expensive; key is to consume a variety of locally available/grown food on a daily basis.

The food pyramid: This provides the different types of food that we should eat for a healthy life. However, the foods at the bottom should be eaten most and those at the top more sparingly. For a healthy diet, a minimum of 5 food groups need to be eaten every day.



- **Separate raw, cooked, and ready-to-eat foods.** Keep raw meat, poultry, fish, or eggs

5. Food handling and preparation

Healthy eating also involves preparing food to preserve nutrients and prevent disease, as well as paying attention to food production issues.

a. Safe food handling and preparation

Food-borne illnesses don't just come from restaurants. In fact, they usually come from bad food preparation, serving, and storage at home.

Follow the guidelines below to keep your food as safe as possible:

- **Wash hands and surfaces often** using hot, soapy water. Wash your hands before and after you handle food or utensils, especially raw meat, poultry, fish, or eggs.
- **Wash all fruits and vegetables** before eating.

away from other foods to prevent cross-contamination. If possible, use separate cutting boards for these foods. If not, be sure to wash cutting boards carefully with soap between uses.

- **Cook foods to a safe temperature.** Uncooked or undercooked animal products can be unsafe.
- **When in doubt, throw it out.** If you are not sure that food has been prepared, served, or stored properly, throw it out.

b. Healthy cooking

When preparing food, aim to preserve the nutrient value of the food and utilize healthy fats, reasonable portions, and whole foods.

Here are a few tips:

- Use healthy cooking methods such as steaming, boiling, grilling and roasting; frying requires adding fat to achieve the desired results.
- Cook foods in as little water and for a short period of time as possible to preserve all water soluble vitamins(Bs and C)
- Use a variety of herbs and spices for additional flavor rather than relying on salt alone
- Avoid packaged or processed foods which contain added salt, sugar and fats

6. Human health in relation to food and nutrition

Human health is viewed differently in different perspectives:

World Health Organization (WHO) gives a more explicit definition of health- "As a state of complete physical, mental, social wellbeing and not merely the absence of disease or infirmity. It encompasses all aspects of human life put together in a way that is comfortable as that one can enjoy a vibrant life in work and play."

When people are healthy, they are more efficient at work. This increases productivity and brings economic prosperity. Health also increases longevity of people and reduces infant and maternal mortality. Balanced diet, personal hygiene and regular exercise are very important to maintain good health.

The health of a person depends on the type and quantity of food stuff consumed. Good nutrition is essential for a person to grow and develop normally and to remain healthy throughout life. When a person does not eat proper food, there are

chances of the body not developing normally. There are chances that some organs of the body may start malfunctioning or there may be some disease. Poor nutrition may also influence the mental and social well being adversely.

Increasingly, poor dietary patterns make the greatest contribution to the burden of non-communicable disease. If we take too much food, or food that gives our bodies the wrong instructions, we can become overweight, undernourished, and at risk for the development of diseases and conditions, such as arthritis, diabetes, and heart disease.

Many researchers now believe that these problems are partly related to the diet. While they used to believe that diseases such as type II diabetes, obesity heart disease, stroke and certain cancers were caused by a single gene mutation, they are now generally attributing these conditions to a network of biological dysfunction. The food we eat is an important factor in that dysfunction, in part because our diets lack the balance of nutrients (proceedings of the nutrition society 2004)

Nutrient deficiencies and food-borne illness also contribute to diet-related disease. These diseases, together with their risk factors, including obesity, hypertension, and hypercholesterolemia, account for significant medical and productivity costs, and they exact a heavy toll on quality of life in the Kenya

Further, over nutrition reduces reproductive capacity and promotes the development of various cancers that will seriously affect quality of life, survival, and reproduction in human beings

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CHAPTER 3: DIVERSIFICATION OF FARM ENTERPRISES

1. Introduction to farm diversification

In the agricultural context, diversification can be regarded as the re-allocation of some of a farm's productive resources, such as land, capital, farm equipment and labour. It involves broadening the activities of a business into other new potential money making ventures.

Diversification may also take the form of adding value to existing production. You may have the expertise within your farm to be able to make process products from fruit crops, or direct market fruit or vegetable production.

In general, diversification refers simply to an increase in the number of enterprises operated on the farm. In practice, this may take several forms. You may grow more than one field crop to spread the work over a longer planting and harvesting season. You may spread the risk over more than one enterprise (such as livestock), or you may add value to a crop you currently produce. Another method of diversification is to utilize your resources to their optimum level. This may take the form of custom planting or harvesting, storing grain for others, or utilizing existing labor or management abilities to their best advantage.

The factors leading to decisions to diversify are many, but include; reducing risk, responding to changing consumer demands or changing government policy, responding to external shocks and, more recently, as a consequence of climate change.

Farms realize benefits by taking on new income generating activities. Diversified farms can enjoy increased personal and farm family success, improved finances, increased efficiency and see redundant farm buildings back in use.

Benefits for farm diversification

The benefits of diversifying a farm include:

- i. making better use of your farm's physical resources and characteristics
- ii. finding new uses for your existing skills
- iii. If you are only engaged in one enterprise (growing tea for example) and have a crop failure, it will be more devastating than if you grew more crops. By diversifying, you are spreading the downside risk over more than one enterprise.
- iv. Increased revenue- by taking on new activities you and your family are likely to enjoy an increased farm income and a better quality of life.
- v. Adaptability- branching out encourages you to be willing to change and look out for other opportunities. By adding a new activity you will learn what works for you and your farm and be better able to make further changes in the future and respond to new opportunities as they arise.
- vi. Security- by moving into new activities, a farm can provide you and your family members with a long term future and greater stability. By branching out you will increase the number of sources of revenue for your farm ensuring that you are less susceptible to any one income source letting you down.
- vii. Develop new skills- running a new venture will provide the opportunity to increase your skills and expand your network of business contacts. From management to marketing and finance to customer service diversifying will develop your business style.

2. Possible farm enterprise options for tea farmers

As a tea farmer, there are few limits on the kind farm business you can diversify into. They can be either agricultural or non-agricultural, such as:

- alternative livestock or livestock products – dairy goats, rabbits, poultry, pigs, dairy cow and their products
- alternative food crops and their products either in raw or in processed form- eg vegetables, fruits, cereals and legumes etc-
- retail outlets and catering - eg opening a farm shop
- fish farming
- non food crops

3. Planning for farm diversification and choice of farm enterprise

To find out if diversification is the right choice for you, you should be ready to analyze:

- why you want to diversify
- the implications on your time, your core farm business activities, cash-flow, workforce, potential liabilities etc
- information about skills, resources and market conditions that you have gained from other local farmers who have diversified
- how much the diversified business will cost to set up
- how you will finance it
- how profitable it will be
- how to market it
- legal requirements

Careful planning is essential to diversifying a farm successfully. Write down your ideas and build your plan gradually. It will take time to develop your plan and it may need to be revised a number of times before you are satisfied with it.

You will also find it useful to keep a list of all of the things you will need to do to get your business started

The key steps involved in farm diversification are:

- Identifying an idea that will work for you. You will need to research your local market and ensure that your idea is viable.
- Shaping a suitable business plan. Planning is essential to your success and will be critical to obtaining financial support.

- Working out how much is required to finance the idea and how to ensure it is secured.
- Working out what is involved in producing and delivering the new product or service from your rural enterprise.
- Working out how you will market and sell your product/service.
- Ensuring you meet any legal requirements.
- Get training to build up your understanding of what is involved in running your own farm business.

There are a number of practical things you can do. It is worth spending time talking through your idea with friends and family and also with your agricultural officers.

Factors affecting farm enterprise diversification.

There are several factors which can influence the decision to diversify. Many of these are socio-economic characteristics of the farm household

1. Risk

Agriculturists are exposed to both price and production risk. Price risk refers to output prices, which are known post-production.

Price risk results from variation in supply and demand of a commodity. Government policies may reduce this risk by the use of intervention, subsidies and quotas. Where uncertainty arises over change in policy, e.g. the future of quotas, risk will be increased

Production risk occurs due to elements such as weather and disease. In harsh climates, weather-induced production risk is greater than price risk (Bhende and Venkataram, 1994).

Individuals perceive and react to risk differently. They may be risk-preferring, risk-neutral or risk-averse.

2. Farm characteristics

The characteristics of the farm itself will carry an important bearing both on the feasibility and the nature of diversified activity. Some of these characteristics relate to the farm structure and others to physical characteristics such as farm size and location

3. Household characteristics

Various characteristics of both the farmer and the farm household will affect their ability and motivation to diversify. Some of these include:

- Farmer personality and perception of diversification
- Age
- Human Capital
- Education
- Number of children
-

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CHAPTER 4: AGRICULTURAL VALUE CHAINS AND MARKETING

1. Introduction to agricultural value chains and marketing

Supply chains- Supply chains are a natural phenomenon of business and exist whether they are managed or not

- All agricultural products reach the end consumers of those products through chains of individual businesses that link primary producers, through various intermediaries, with retailers. These chains, which are commonly referred to as supply chains, may be very simple or very complex.
- Nevertheless, each business in a chain is a customer of the business immediately upstream of it and a supplier to the business immediately downstream of it. For example, a farmer is the customer of a fertiliser supplier or a bank, and the supplier to a processor or a wholesaler.
- business in a supply chain aims to maximise their individual benefit by competing for cheaper inputs and higher prices

While this kind of self-interest may appear to be rational economic behaviour for individual businesses, there can be negative consequences for the chain as a whole, as the following examples illustrate:

- Consumers may not get what they want because signals from consumers are not transmitted clearly, or at all, back up the chain.
- Waste and inefficiency can go undetected.
- Weaker members of the chain can be exploited by more-powerful members.
- Chain-wide responsibilities such as meeting environmental or food safety standards may be ignored by some members of the chain.

Agricultural value chains include the flow of products, knowledge and information between smallholder farmers and consumers. They offer the opportunity to capture added value at each

stage of the production, marketing and consumption process.

It can also be defined as a market-focused collaboration among different stakeholders who produce and market value-added products. Smallholder farmers need to better engage with value chains in order to gain added value for improving their livelihoods, whilst reducing their risks and increasing their resilience

If agricultural value chains are to offer pro-poor opportunities for growth and development, then those markets in which smallholders can have a 'comparative advantage' need to be identified and the producers actively assisted.

Smallholders within a producer or marketing group can use this social network to strengthen their position within a value chain.

Value chains as systems

Thinking about the chain as a whole having to 'perform' requires thinking about the chain as a system, because its performance is a function of the interactions among its parts.

Thinking about producer-to-consumer chains as systems does not detract from the need for individual businesses in a chain to be profitable. On the contrary, it brings an additional focus to the performance of the entire chain and how improved chain performance as a whole can contribute to the profitability of individual businesses.

A value chain is a set of linked activities that work to add value to a product; it consists of actors and actions that improve a product while linking commodity producers to processors and markets.

value-chains enable improvements in product and information flows via the strategic alliances and networks, relationship management and

governance structures that are necessary for promoting innovation in product development, production and marketing to satisfy consumer demand

As interactive systems, effective value-chains involve flows of products, money and information enabled by relationships among chain members

Value chains work best when their actors cooperate to produce higher-quality products and generate more income for all participants along the chain, as opposed to the simplest kinds of value chains, in which producers and buyers exchange only price information.

Value chains differ from supply chains, which refer to logistics such as: transport, storage and procedural steps for getting a product from its production site to the consumer.

A value chain encompasses the flow of products, knowledge and information, finance, payments, and the social capital needed to organize producers and communities.

Information is especially important to all value chain actors and flows in two directions: markets inform producers of price, quantity and quality needs, product handling and technology options, while producers inform processors and markets on production quantities, locations, timing and production issues. In a value chain, processors and marketing agents may provide producers with finance, inputs and training in technologies of production.

Value chains may include a wide range of activities, and an agricultural value chain might include: development and dissemination of plant and animal genetic material, input supply, farmer organization, farm production, post-harvest handling, processing, provision of technologies of production and handling, grading criteria and facilities, cooling and packing technologies, post-harvest local processing, industrial processing, storage, transport, finance, and feedback from markets.

Agriculture in developing countries often is characterized by dual value chains operating in parallel for the same product: one informal or traditional and the other formal or modern.

Small holders are frequently involved in informal chains that deliver products to local middlemen and then to small local stores.

Formal value chains can deliver the same product, usually in better or more uniform quality, from larger farms or more organized groups of small farmers to more commercial wholesalers and from there to supermarkets or exporters. This duality has been accentuated by the explosive growth of supermarkets in developing countries. It can limit many small producers to markets characterized by low-quality products, and low prices and low returns for them — hence a frequent concern is to find ways to integrate small producers into more modern value chains, both domestic and export-oriented.

The value perspective of chains as systems

- Value chains aim to satisfy consumer demand while making profits for members of the chain.
- Knowing what consumers want and how to profitably satisfy those requirements are therefore key questions in improving the performance of chains.
- These questions revolve around the concept of consumer value because consumers attach value to products and services they are willing to pay for, and chain members are able to profit from creating and delivering consumer value.
- When an agrifood chain is viewed as a system whose aim is to profitably create and deliver value to consumers, it is called a value-chain
- Agricultural value chains include the flow of products, knowledge and information between smallholder/large scale farmers and consumers. They offer the opportunity to capture added value at each stage of the production, marketing and consumption process.

Value-chain thinking

- One way of characterizing value-chain thinking is to contrast supply chains and value-chains. Consumers decide whether they are going to buy the product and how much they are willing to pay for it.

Value-chain thinking increases farmers' incomes when they:

- understand market opportunities and focus on producing what consumers in those markets want; and
- become preferred suppliers by providing superior service to their customers, for example in terms of reliability.

Understanding the consumer

- The 'understanding consumers' part of the first piece of the value-chain thinking that lead farmers need think about:
- Which products, and what characteristics of those products, are shoppers looking for?
- Which crops should I grow, and which varieties? Which livestock should I raise, and of which breed?
- How much should I grow, and how should I grow it?
- *Can I process the product to make it more attractive/valuable to consumers?
- *Which potential customers can best serve the consumers being targeted?
- *What are these customers' priorities?
- *How can I contribute to meeting these requirements?

Note

- **In most cases, the more value you create, the more people will be prepared to pay a good price for your product or service, and the more they will they keep on buying from you. On a personal level, if you add a lot of value to your product, you will excel in what you do. You should then expect to be rewarded in line with your contribution.**
- **Value chains work best when their actors cooperate to produce higher-quality products and generate more income for**

all participants along the chain, as opposed to the simplest kinds of value chains, in which producers and buyers exchange only price information

An agricultural value chain may include:

- development and dissemination of plant and animal genetic material,
- input supply,
- farmer organization,
- farm production,
- provision of technologies of production
- post-harvest handling,
- grading criteria and facilities,
- processing- (local processing, industrial processing),
- cooling and packing technologies,
- storage,
- transport,
- finance,
- and feedback from markets.

Benefits of agricultural value chains

Given the economic importance of agriculture in Kenya, improving the functionality and the accessibility along the whole agricultural value chain can bring multiple benefits for smallholder farmers.

- Participation in well-functioning value chains can offer job opportunities, services and connective infrastructure linking to wider markets.
- Rapidly growing global food markets can help to expand these benefits and share value across value chain participants.
- In some instances participating in a well-functioning value chain brings farmers not necessarily higher prices or incomes, but a more stable, resilient and predictable income.
- More than 80% of the value in the global food industry is in 'value-added' components ranging from sorting, cleaning and packaging for fruits and vegetables to processing and branding foods and beverages. Some of these value-added activities require skills, financing and

scale, but simpler changes can also capture higher value.

These activities can provide a way for farmers to expand and access higher-value national, regional or international markets. They can also provide greater employment opportunities, especially for women who are particularly active in food processing.

Contract farming allows farmers and buyers to better coordinate their efforts; which allows for a degree of assurance improving some of the main areas of risk: price, quality, quantity and time of delivery.

Although farmers have benefited from contractual agreements, there is substantial evidence that the smallholder farmers are often unable to enter formal arrangements.

Cooperatives have also come back into favour with donors and NGO's as a way to facilitate smallholder participation in a particular part of a value chain (such as production, post-harvest handling or marketing), or control entire chains. However, larger cooperatives may require a hierarchical system to be put into place for effective coordination.

As cooperatives are typically based on voluntary membership, joint interests and participatory decision-making, imposed hierarchical structures can prove challenging.

In recent years there has been a shift that focuses greater attention on staple and other food value chains, where small -scale producers , especially women, tend to be more active . If development is built among resource-poor women, they can engage in economic activities that will improve their livelihoods.

Some of the women initiatives have shown that when women pull their resources together and receive adequate support and accompaniment, they can engage in higher value markets (such as in processing), increase their control over several stages of value chains and even become involved in the coordination of the value chain.

Whilst agricultural value chains offer new income earning opportunities, they can also create barriers to market access for smallholders. In some cases, the concentration of market power at specific points in the value chain reduces the incomes of other actors, particularly those exposed to high levels of risk such as smallholder farmers and women.

To reduce the risk borne by those at the base of agricultural value chains, more work is needed to identify the types of markets where smallholder farmers can have a 'comparative advantage' and identify the types of support that will enable them to harness greater value.

Support may come in the form of inter-professional associations or 'innovative platforms.' These are private bodies, recognized by the state, which group together upstream and downstream partners of the same commodity along a value chain. They aim to make the value chain more efficient by identifying and overcoming bottlenecks. They are a form of bridging capital (links across communities) that offers a way to deal with the multiple stakeholders – farmers, traders, processors, input and credit suppliers, insurers, policymakers and researchers – involved in a commodity value chain.

2. Analyzing and understanding agricultural value chain, market and market research.

A value chain analysis approach in agricultural development helps identify weak points in the chain and actions to add more value.

Value Chain Analysis is a useful way of thinking through the entire value chain of the product you are dealing with and developing ways in which you deliver value to your customers, and reviewing all of the things you can do to maximize that value

“In business, we're paid to take raw inputs, and to “add value” to them by turning them into something of worth to other people. This is easy to see in manufacturing, where the manufacturer

“adds value” by taking a raw material of little use to the end-user (for example, wood pulp) and converting it into something that people are prepared to pay money for (e.g. paper). But this idea is just as important in service industries, where people use inputs of time, knowledge, equipment and systems to create services of real value to the person being served – the customer”.

In most cases, the more value you create, the more people will be prepared to pay a good price for your product or service, and the more they will they keep on buying from you. On a personal level, if you add a lot of value to your product, you will excel in what you do. You should then expect to be rewarded in line with your contribution

Value Chain Analysis is a three-step process:

1. **Activity Analysis:** First, you identify the activities you undertake to deliver your product or service.

The first step to take is to brainstorm the activities that you undertake that in some way contribute towards your customer’s experience. At a business level, this will include the step-by-step business processes that you use to serve the customer. These will include marketing of your products or services; sales and order-taking; operational processes; delivery; support; and so on (this may also involve many other steps or processes specific to your business).

At a personal or team level, it will involve the step-by-step flow of work that you carry out. However, it could also involve other activities.

For example:

- How you recruit people with the skills to give the best service.
- How you motivate yourself or your team to perform well.
- How you keep up-to-date with the most efficient and effective techniques.
- How you select and develop the technologies that give you AN edge.

- How you get feedback from your customer on how you’re doing, and how you can improve further.
2. **Value Analysis:** Second, for each activity, you think through what you would do to add the greatest value for your customer.

Now, for each activity you’ve identified, list the “Value Factors” – the things that your customers value in the way that each activity is conducted.

For example, if you’re thinking about a tree seedling business, your customers will value an elaborate explanation of how to care for the seedling after planting; a polite manner; efficient taking of order details; fast and knowledgeable answering of questions; and an efficient and quick resolution to any problems that arise.

If you’re thinking about delivery of a professional service, your customer will most likely value an accurate and correct solution; a solution based on completely up-to-date information; a solution that is clearly expressed and easily actionable; and so on.

Next to each activity you’ve identified, write down these Value Factors.

And next to these, write down what needs to be done or changed to provide great value for each Value Factor.

3. **Evaluation and Planning:** Thirdly, you evaluate whether it is worth making changes, and then plan for action.

By the time you’ve completed your Value Analysis, you’ll probably be fired up for action: you’ll have generated plenty of ideas for increasing the value you deliver to customers. And if you could deliver all of these, your service could be fabulous!

Now be a bit careful at this stage: you could easily waste your energy away on a hundred different jobs, and never really complete any of them. So

first, pick out the quick, easy, affordable wins – go for some of these, as this will improve your spirit and that of your team.

Then sort out the more difficult changes. Some may be impractical. Others will deliver only small improvements, but at great cost. Drop these. And then prioritize the remaining tasks and plan to tackle them in an achievable, step by-step way that delivers steady improvement and at the same time keeps your team’s enthusiasm going.

There are three components of value chain analysis: network structure, value added and governance structure.

A network structure has two dimensions: vertical and horizontal. The vertical dimension reflects the flow of products and services from primary producer up to end-consumer (i.e. the value chain or supply chain). The horizontal dimension reflects relationships between actors in the same chain link (between farmers, between processors, etc.)

Value added is created at different stages and by different actors throughout the value chain.

Value added may be related to quality, costs, delivery times, delivery flexibility, innovativeness, etc. The size of value added is decided by the end-customer’s willingness to pay. Opportunities for a company to add value depend on a number of factors, such as market characteristics (size and diversity of markets) and technological capabilities of the actors.

Moreover, market information on product and process requirements is key to being able to produce the right value for the right market. In this respect finding value adding opportunities is not only related to the relaxation of market access constraints in existing markets but also to finding opportunities in new markets and in setting up new market channels to address these markets.

Value adding in food production focuses in particular on safety and quality of the product. Quality can be divided into intrinsic characteristics

of the product itself (e.g. color, taste, tenderness) and extrinsic characteristics of the process which cannot be measured on the product (e.g. organic or fair trade production).

Governance and bargaining position of value Chain Actors. -Firms in value chains are linked in a variety of sourcing and contracting relationships, i.e. forms of governance

Benefits of value chains analysis.

- Helps understand process, stakeholders and relationships
- Helps to identify problems or opportunities to improve contribution of specific actors and overall performance
- Highlights who is benefiting most and possible barriers to entry
- Enables understanding of dynamic competitive factors within whole value chain and global dispersion of production
- Policy and restructuring tool to counter market and state failures and direct investment and support.

Examples

- i. The analysis of the dairy value chain may identify critical needs such as:
 - The need for more local milk cooling points,
 - more collaboration between dairy plants and farmers
 - and greater diversification of final products.
- ii. The analysis of a fish value chain may identify:
 - a need for fishermen to deliver more uniform-sized fish to processors,
 - for government to enforce corresponding regulations and for processors to offer fishermen contracts that contain credit.
- iii. A cassava value chain analysis may identify issues such as :
 - issues regarding depletion of soil fertility (unsustainable farming methods),

- management of wastewater from starch plants/industries,
 - and the need for better direct links between small farmers and processors.
- iv. Sorghum value chain. The analysis may identify issues such as:
- Poor quality of seeds and varieties inappropriate for the various uses.
 - Poor quality of product at harvest, with grains of inconsistent size and coloration.
 - Inadequate threshing techniques and post-harvest drying and storage, which reduce quantity and market quality.
 - Inadequate grading.
 - Insufficient market development and communication with markets regarding varieties and quality of sorghum desired.
 - Insufficient training and finance for improved post-harvest management.

The analysis underscored the importance of sorghum growers and breeders recognizing that managing for food quality can increase their access to more markets.

These issues on the sorghum value chain may be addressed by: the factory/buyers offering farmers production contracts with guaranteed prices along with quality requirements, this can led to many more farmers to grow the grain.

The livestock value chain can be defined as the full range of activities required to bring a product (e.g. live animals, meat, milk, eggs, leather, fibre, manure) to final consumers passing through the different phases of production, processing and delivery

Value chain analysis is essential to an understanding of markets, their relationships, the participation of different actors, and the critical constraints that limit the growth of agri-business and consequently the competitiveness of smallholder farmers.

Small scale farmers currently receive only a small fraction of the ultimate value of their output, even

if, in theory, risk and rewards should be shared down the chain.

Access to markets and distribution of risks and gains along different steps of value chains varies also according to the gender of producers (e.g. rights to income generated from product); processors (access to processing technologies and information); market agents (access to transportation, safe market spaces and overnight accommodation, risk of sexual harassment and abuse); and according to the economies of scale (bringing women together to improve their market position).

Strategies to improve: value chain participation

- Empowerment: Empowering poor smallholders, men and women, so that they can provide high-quality, sustainable produce with an identified market destination (by assuring adequate access to basic production inputs, credit, capacity-building, market-related information);
- Supporting an enabling environment: Facilitating poor farmers' access to markets as a catalyst for poverty reduction (by improving their business management skills and marketing strategies, ensuring that they have the knowledge and technologies required to meet quality and sanitary standards, providing adequate infrastructure);
- Equity: Ensuring that the economic gains in value chains are fairly distributed among the various actors, including poor farmers (by reducing marketing distortions, building relationships among various chain actors, strengthening farmers' organizations and livestock traders' associations).

Market dynamics

A market can be described as a place where buyers and sellers transact their business.

Marketing is a process of identifying and satisfying the consumer needs in a most efficient manner and at a profit. Marketing is the most important aspect in business because even with the latest technology today one can manufacture a

product and if that product is not bought it will be useless.

It is better to produce for an identified market, rather than trying to sell what the farmers have already produced and then seeking new market opportunities.

Direct communication between end buyers and producers can be a powerful tool in helping producers to understand the implications of competitiveness.

Market survey/ research

This is a systematic, objective approach to the development and provision of information for marketing decision making, this definition emphasizes

1. that marketing research is a planned, well organized process,
2. the information obtained in research is not biased by the interviewer or by the interviewing process,
3. the information is gathered for the purpose of helping managers make decisions

Marketing research can give a farm business a picture of what kinds of new products and services may bring a profit. For products and services already available, marketing research can tell farmers whether they are meeting their customers' needs and expectations. A good market research plan indicates where and who your customers are. It will also tell you when they are most likely and willing to purchase your goods or use your services.

When you conduct marketing research, you can use the results either to create a business and marketing plan or to measure the success of your current plan. That's why it's important to ask the right questions, in the right way, of the right people. Research, done poorly, can steer a business in the wrong direction.

Here are some market-research basics that can help get you started and some mistakes to avoid.

Conducting market research can include:

- Interviews (either by telephone or face-to-face)
- Surveys (online or by mail)
- Questionnaires (online or by mail)
- Focus groups gathering a sampling of potential clients or customers and getting their direct feedback

Some important questions might include:

- What factors do you consider when purchasing this product or service?
- What do you like or dislike about current products or services currently on the market?
- What areas would you suggest for improvement?
- What is the appropriate price for a product or service?

Points to consider when carrying out a market survey.

- Asses the demand of your customers,
- Know your competitors and their advantages
- Know your customers and their characteristics

Some important questions might include:

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- What do you like or dislike about current products or services currently on the market?
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Attributes for successful marketing

- These are qualities of “knowledge”, “knowhow” and “social skills that are required for successful marketing, and may be useful to both direct value chain actors and support institutions These qualities are listed in the below:

sufficient time to think (and calculate) before acting.

Knowledge	Know-how	Social skills
<ul style="list-style-type: none"> Master marketing concepts Develop broad knowledge on the economics of agricultural products, value chains, etc. How to identify market needs Etc 	<ul style="list-style-type: none"> Analysis of information and the situation Understand a situation and propose appropriate solutions Develop a vision for the development of an ABC Be able to anticipate market evolutions, with the help of good information Being able to adapt theoretical tools to a specific ABC's context Obtaining the participation of a many ABC members Etc. 	<ul style="list-style-type: none"> Listen to actors Be curious Be creative, innovative Stay humble Be dynamic, enthusiastic, committed Respect the other, and be respected Etc.

Market Variables (5- Ps in Market consideration)

- Product.**-A product is anything that is offered to customers for acquisition or purchase. This embraces physical objects, personalities, services, places and ideas which are offered to the market for acquisition or consumption. The appearance of the product should be attractive if the customers are to be interested in buying it.
- Price.**-The price will tell the quality of the product, it's important to mix the product with the price, if the quality of the product is of high quality it will cost high and Vis avis.
- Promotion**-The way by which we make the customers aware of our product will decide the kind of sales we will get.
- Place**-This is the channel of distribution hence we should put this in mind as we want our product to reach all kinds of people.
- People**-They are basically the customers that we receive, who should have the money to spend on the product; they must also have the right to spend the money on purchases of their choice.

What are the possible negative/dangerous effects of a successful marketing action?

- A growing demand: There will be a need for a new internal organization, strengthening capacities, etc.
- A growing greediness of some members and consequently possible internal problems.
- Smaller members could be left behind, which may create internal problems.
- Farmers may be tempted to demand higher prices: it will be the duty of the BSS to sensitize people to the risks of price construction and to the need to reduce costs.

Advice: stay realistic, develop a professional behaviour within the ABC through a good internal communication, through joint decisions, and take

Marketing Variable	Marketing questions	Skills to learn
People	Who are my customers?	State your major target customers. They should be enough to consistently buy your product/service. These are people who you will ensure are the first to know you are in business and their purchases forms the foundation of your sales. They can be individuals, companies, other entrepreneurs, organization, local, regional, national or international.
	What do they like? What do they need?	Services/product that will make them happy because their needs have been met/their problem has been solved.
	Do they have money to buy my products?	Consider the capacity of the people to afford your service/ product. This largely determines their interest (interest + affordability is known in business as demand).
	How do I make or get	You should make your product in such a way you reduce

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Product	the product?	the cost of production while maintaining standards of high quality.
	Does it meet the customer's needs?	A product that solves a problem/need among the people is what will be bought. Such can only be developed after you conduct a market research (market need assessment).
Place	Where will I start my business?	Very important to consider the location. First, it must be easily accessible to customers, Second, consider the impact of location to your overall cost of business (do you have to pay rent? Are your products safe?).
	Is it convenient for the customer?	Customers will always spent their money at a place that is convenient to them (they never want to feel extra -burdened to spend) consider distance from the customer or availability transport.
Price	How much will it cost to get the product to the customer?	The cost of production must be the minimum possible for production of a quality product. This will ensure your prices are competitive while at the same time raising profits.
	How much will they pay?	Determine your price after considering your overall expenses of production, the other prices in the market and profit you want.
	Will I make profit?	This is determined after you have taken into account all the costs involved until the product gets to the customer and comparing the market price by your competitors.
Promotion	How will I let people know that I am in business?	Use the most effective and affordable means of advertisement. This depends on the type, distribution and exposure of your customers and also the type of product/service.
	How will I attract them to my business?	Things that attract people to business are simple: <ul style="list-style-type: none"> • Use of good language while talking to customers. • Showing interest in them when you are talking to them (simple gestures like a smile means a lot) • good packaging, display and presentation of your products. • Talk to people positively and confidently about your product
	How will they know my product is better than another?	You should try to have samples or demonstrations of your product or service and confidently tell people that your product is the best.

3. Marketing

Marketing contributes to improve small scale farmers' livelihoods and hence leads to poverty reduction. One of the major causes of high levels of poverty among small scale farmers are low producer prices and high input costs.

Farmers have limited skills, knowledge and information in production and marketing to compete on local and international markets, have limited access to financial capital for investment and are not organized to take advantage of opportunities in domestic and international market chains.

As you plan to start your business your marketing strategy is what will give you to your first customers, retain them and progressively give you more, How you will get the consumer to buy your product or service more than someone else's.

1. You should understand your customers very well. Recall that shop owner in your market centre or town who you can simply make a phone call to and he will give your children what they need when you are far, or a barber (kinyozi) whom you don't have to struggle explaining to how you want your hair or your child's done. This entrepreneur understands you and that retains you as his/her customer.

Have you ever received a call from a business lady/man informing you that she has just arrived with your favourite dresses, perfume or even vegetables? Do you have a service person who understands your equipment, car or electronic so well that you only trust them to fix or service it? Without him you will wait until they come back from a two weeks journey? Such a business person understands his /her customers and this does two things:

- It retains the current customers.
 - It increases your customers because customers that are happy with you will refer their friends to you and hence effectively promoting your business.
2. You should endeavour to satisfy their needs Recall an instance when you walked into a shop and asked for an item only to discover that the shopkeeper has never stocked it or even he doesn't know it. But the story doesn't end there, this lady/man engages you in a conversation about the product you asked. Asking you about why you like it, how good it is, at what price have been buying it, how often do you use it, then he says that he has had several people requesting for it and for that reason he assures you will get it the following day.

This is a business person who is committed to understanding and satisfying his customer's needs.

How do you engage your customers?

- Talk positively and confidently about your service or product at any slightest opportunity you get to everyone you meet.
- Make business cards brochures that have all your contacts and give them to potential customers you meet.
- Identify influential people within the society (local leaders, religious leaders and managers and heads of institution, companies and organizations) and introduce them to your business and request them to tell to those under them.
- Have an interest in lives of your customers (this is what large companies call 'social responsibilities' a customer who saw you attend or contribute when he/she lost a beloved one is most likely to buy your services/ product than buying from one who did not show concern.

Consider two business persons selling the same product at the same price, a community in which they are doing business has decided to work together and repair their road and water borehole. One of the businessmen participates in the project together with his family, the other doesn't. Who will have more customers?

Pillars of successful marketing strategy

1. Be self-reliant.
2. Be diplomatic when dealing with people.
3. Be determined and never despair.
4. Be proficient and honest.
5. You have to study the market and know where the appropriate place you can work in and succeed.
6. Evaluate yourself according to your talents and abilities and choose what you want.
7. Be aware of what is going on around you
8. Study the market before you make any step
9. To be a successful entrepreneur you should be a good accountant and manager

Marketing constraints faced by producers (farmers)

- a. Financial constraints that manifest themselves in form of; inadequate financial resources for investment, too high interest rates on borrowed funds and unfavorable terms of borrowing. One farmer observed that: “borrowing these days is a recipe for loss of my property and am not ready for that.” small scale farmers require financial assistance to buy farm inputs- seeds and fertilizers; storage/safety houses; purchase of harvesting materials; land preparation mainly slashing; preservation/drying equipment, training and transport.
- b. Limited participation of farmers in the marketing chain.
- c. Lack of information on market requirements- such as quality, quantity, prices and location.
- d. Limited skills and knowledge of improved agricultural technologies resulting in a slow rate of technology adoption, high post harvest losses, poor quality products and generally low production levels.
- e. Lack of organized and strong farmer groups to negotiate in the market. Farmers remain price takers as traders determine prices through deliberate distortion of market information.
- f. Inefficient and costly transport systems. Roads at all levels in production areas impassable leading to isolation of farmers in the rural areas. Modern transport methods do not work in these rural areas making accessibility to markets impossible.
- g. Limited reliable and knowledgeable rural input suppliers for genuine inputs. There are few input suppliers in the rural and even the few sometimes sell fake seeds, fertilizers and acaricides which affects farmers production

levels, quality and hence incomes. Input suppliers are not controlled and they sell everything they want.

4. Mobilization of farmer production and marketing groups

Farmer’s mobilisation and aggregation is one of the most effective means of reducing the risk in agriculture and strengthening the livelihoods of small holder farmers. By working together through farmer groups and Farmer producer’s organisations, farmers have better capacity for and access to technical know-how on crop planning and management, inputs (including seed production), credit, post-harvest management, value addition, marketing infrastructure and better market linkages.

The approach also helps small holder farmers in accessing various benefits of government schemes for rural development. The process involves mobilizing farmers into groups of between 15-20 members at the village level as Farmer Interest Groups (FIGs) and building up their associations to an appropriate federating point i.e. Farmer Producer Organisations, or farmer marketing organisation. The two structures should be strengthened to address the challenges of access to investment, technology, quality inputs and integration with markets that the small holder farmers face. This aims at improving the production, productivity and profitability.

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CHAPTER 5: FARM MANAGEMENT

1. Introduction to farm management.

Farm management is a science that deals with the proper combination of production factors which include land, labour, capital and management to bring about a maximum and a continuous return to the farmer. It involves an analysis of how to make a farm profitable and how farm production decision is made. It also involves the allocation of scarce resources for the fulfillment of human goals in the world characterized by risks and uncertainties

Management of a farm enterprise basically has the same underlying objective as any other business; it aims at improving the benefits to the farmer or group of farmers. This is generally done by following two approaches.

- Focusing on reducing farm expenses by optimizing the use of the farm own resources.
- Focusing on minimizing production and financial risks; which may be caused by: un-favourable climatic situation, pest and disease attacks and price fluctuations.

One of the most valuable resources of an ecological farm is the fertility of its soils as it ensures the long-term productivity of the farm. While proper diversification of crops and animal products will improve the market opportunities and help to reduce production and financial risks.

The farmer, as the manager of the farm enterprise, is at the centre of all farm activities.

- The farmer is the overall decision-maker to determine the farm development goals and how well the farm will perform.
- He/she makes decisions on what to produce and where, how much to produce, what methods of production; where to sell and how, etc.

However, in order to take the right decisions, he/she needs to do a proper assessment of the farms resources and potential, expenses, outputs and the resulting profit from the farm activities.

This will be followed by proper planning, organizing and monitoring of the farm activities in a continuous and cyclical process.

The farmer, therefore, continuously needs new information and knowledge by attending trainings, meetings and discussions with other farmers. It further requires him/her to be proactive to try and test new practices, varieties and breeds in order to continuously improve the farm.

Common limitations to proper farm management include:

- Limited sources of farm income –For most farmers, farming is done with the primary objective to generate enough food for household consumption. Any surplus is then sold to the market. The obtained money helps farmers to access products and services that the farm cannot produce: cloth, household and school items, etc. most tea growing farms tend to be rather small and growing limited options of nearly the crops, most farmers are not able to meet all their basic requirements from the farms. This is because they are normally affected by the same production and marketing risks.
- Limited saving potential- Majority of farmers have poor saving culture as well as limited capacity to make savings that can enable them to invest in long term improvement of production conditions. The income from production is rather spent on household needs related to food, education, health care, and social commitments (i.e. marriages, funerals). This leaves little or no money for re-investment back into farm activities.
- Limited farm size for production- land fragmentation is a major problem in densely populated areas leading to small farms sizes for productive agriculture. Under such conditions, farmers may not be able to produce enough food to make a reasonable living. In addition, highly intensive and potentially more profitable enterprises like vegetable

production, poultry keeping, honey production, etc. may be limited due to lack of experience, knowledge and capital to invest.

- Labour shortage -The increase in the number of school-going children, rural urban migration, drug and substance abuse and other society menace have lead to widespread scarcity of labour available in most rural areas. This is especially critical in crops like tea, coffee, etc where there is high labour requirement either during management or harvesting. This implies that labour costs have risen to a level which may not be profitable anymore for a typical farm.

Although the above challenges may slightly differ between small and big farms, their effects to proper farm management remain the same.

Most small-holder farmers in Kenya do not treat their farms as a business entity. In other words, they grow crops or animals the way their parents did or the community has been doing for generations.

Proper reflection and setting of farm goals for farm development to meet present and future income needs is very rare. Treating a farm as an enterprise involves careful analysis of the farm resources and potential in order to understand the full potential of the farm. This is then compared with the way the farmer is currently utilising those resources to identify any gaps or necessary improvements. This is followed by the careful selection of crop and animal enterprises and practices, needed to improve short- and long-term productivity of the farm.

2. Farm planning and layout

Farm planning is the process of preparing a set of interrelated activities to be implemented within a specific time frame and the allocation of necessary resources, needed to achieve the desired situation. The aim is to have an organized and consistent way of allocating resources among the different enterprises to achieve the best results and minimize wastage and redundancy.

Proper planning is one of the key management aspects that need to be regularly practiced. It provides a road map and direction for transforming the farm from the current status to a desired farm situation or to maintain the route towards a chosen goal.

The result of the planning process is the ‘farm plan’, which acts as a guide for carrying out the required activities to achieve desired results and effect desired change.

Factors influencing farm planning

1. Data availability -The major prerequisite of farm planning is data availability (both quantitative and qualitative)
 - ✓ Quantative data refers to the prices of direct inputs and outputs, labour, and capital.
 - ✓ Qualitative data refers to farm history i.e. diseases, pests etc which is important in crop rotation
2. Data quality -Refers to reliability of data. The data should have minimum error and to be up to date

There are three elements in farm planning

- ✓ Objective setting

The major objective in planning is maximization of profit under the given circumstances. Without objectives, there is nothing to guide the farmers course of action

- ✓ Statement of suitable enterprise

Enterprises make use of resources and there are many enterprises that one can implement in a farm. We have to rate and prioritize them based on their economic returns on resources. Data collection and analysis will give us the necessary information to make informed decisions on the suitable enterprise. Such decisions may be based on the prevailing ecological conditions, available technology, prevailing social and cultural aspects, economic positions and local or national policies. The enterprise statement will include both the returns and requirements.

✓ Statement of available resources

These details the available resources from the planning frame work. They are at the same time regarded as constraints which to a large extent determine the implementation of activities.

A statement of resources will include –type, quantity, quality and timing of utilization. NB. We have to identify the most scarce resource so that we can maximize returns from them e.g. if you have land shortage we select labour intensive enterprise with high returns /ha , if labour is in short supply we select an enterprise and technology with higher returns on labour.

Steps in Farm planning

a. Identification of farm problems/issues.

Problems/issues are solved through proper farm management; if you have no problems then management becomes a routine activity with no specific objectives and no particular difficulties to deal with. All problems are centered on the capital aspects although some may seem to be human in nature. Observations have to be made and analysis is the first step towards finding the solution and setting goals.

b. Resource mapping-

Resource mapping is the process of identifying of all the physical, land and water resources available on their farms. This is done by drawing a clear farm map including all its elements eg crops and livestock elements, soil types, bushes/forests, water sources, hills, valleys, and all features like roads and buildings. Additionally the amount of labour available, total size of land, access to water, tools available, types and number of animals are identified and listed.

The exercise of resource mapping helps farmers to:

- i. Identify the kind of resources available on their farms.
- ii. Realize how much of the resources are currently being utilized.
- iii. Understand quantities of resources entering (inputs) and leaving (outputs) the farm every season.

- iv. Plan how to benefit more from utilized and unutilized resources in order to improve the farm, for example allocating labour more efficiently to various farm enterprises

c. Evaluation of the present farm status and setting goals/objectives

Having identified the general problem(s) to be addressed, and all resources available on the farm, its present status can be evaluated in relation to what farmers may want to achieve.

By comparing the characteristics of an ideal ecological farm and the current situation of the farm, farmers are able to set both short- and long-term goals for their farms.

The most important part of the farm plan is to be clear of what the farmer, the group of farmers or the community wants to achieve. That is, the purpose and expected outcome over a specific period of time. It includes the expected change that the farmer or group of farmers wants to achieve, after analyzing the present situation.

Without a goal, we have nothing by which management can be guided. Therefore, the goals/objectives should be made specific and achievable within the farm situation and the given time frame.

The long-term goals can refer to the any of the following general criteria:

- Diversifying sources of income
- Minimizing dependency on external inputs
- Increasing farm yields
- Efficient use of resources such as labour and area.
- Value addition on the farm
- Improving profitability of the farm

Examples of specific short-term goals include:

- Introducing other crops on the farm to meet crop rotation and intercropping requirements.

- Expanding on the area under production of crops and to utilize labour more efficiently through better planning.
- Introducing animals to the farm in order to have an on-farm source of manure, and increasing income sources on the farm.
- Establishing enough on-farm sources of food, feeds, seeds, manure, pesticides or firewood/energy sources so as to minimize off-farm purchases.
- Constructing a farm store in order to add value to farm products so as to increase income and profitability.
- Initiating on-farm or off-farm non-agricultural activities that will increase income.

d. Analysis of the current situation and profitability of the farm.

This step is whereby the current production situation and profitability of a farm are analyzed. The evaluation of the current profitability of the farm is necessary, when one of the goals of the farm is to improve profitability. This involves comparing the amount of money spent on various farm production activities (expenses) and the money received from the farm outputs (incomes). The difference between the total expenses and total income will indicate how much money the farm is currently making as (profits).

In this sense, the profit of the farm represents the amount of money that the farmer is left with, from the total amount he/she receives from various sources and what was paid out for all the work, materials and services used on the farm.

From this profit, the farmer is able to pay for household expenses, make investments, and save part of it. In addition to financial profitability, ecological farming may offer to the farmer and his family many other benefits such as satisfaction, a healthy living and others. These benefits are, however, difficult to calculate in terms of money. Although they are not included in the calculation of the current profits from the farm activities, they

will greatly contribute to the future profitability of the farm.

Main sources of farm income (money) include:

- Selling farm products like crops, animals, animal products (e.g. milk, eggs), seeds, other planting materials, manure, mulching materials or other farm products (e.g. timber, firewood, charcoal, bricks).
- Hiring out of labour, tools, machinery or renting of land.
- Charges and donations collected from visitors to the farm.
- Off-farm activities or services like brick making, charcoal making, harvesting of wild products, etc.

Main farm expenses include:

- Household needs - These are costs associated with the well-being of the farmer and his family, e.g. food, water, health, education, accommodation, clothing, entertainment, etc.
- Farm variable costs - These are costs that the farmer pays for whenever he needs to perform an activity or to increase production. Variable costs include cost of seeds or planting materials or animals to keep, manure, mulching materials, labour (including family labour), fuel, packing materials, annual or seasonal land renting, hiring of equipment, etc.
- farm fixed costs - These are costs that the farmer pays for an item once, but which he continues to use for a longer period of time. Farm fixed costs include rent (if land is hired) or purchase of land, farm buildings, machinery, tools, etc.

e. Investing in long-term productivity of the farm

This involves identification of clear and specific activities and innovations to achieve the set goals. The activities should demonstrate how the goals will be achieved.

The productivity of a farm depends on several factors (e.g. farm output, production risks, costs of production, access to markets).

This implies that the productivity of the farm can be improved through any of the following strategies:

- Increasing crop and animal production in the farm
- Minimizing the potential risks to crop and animal production
- Adding value in order to obtain better prices or accessing premium markets
- Reducing production costs especially for farm inputs
- Engaging in other income generating activities to supplement farm income.

Application of sustainable ecological agriculture helps farmers to increase farm productivity through the following strategies:

i. Reducing production risks

The potential negative implications of drought, pest, disease or parasite damage and postharvest losses are minimized through application of ecological agriculture practices. This also the minimizes production and financial risks by encouraging crop and animal enterprise diversification, building up soil fertility, and limited reliance on external inputs which together minimizes the production and financial risks.

Highly diverse ecological farms with a range of crops will suffer less yield fluctuations. If one crop fails, another crop will be harvested to make up for the loss, and in case market prices fall, there is enough security from the other enterprises. ecological farms employ another risk management strategy of lowering production costs by substituting the buying of most off-farm inputs with on-farm inputs.

ii. Improving overall production

In ecological farming, the total farm production is primarily improved by use of tolerant crop varieties and animal breeds, which give good yields under local conditions. Crop yields are also

increased through better soil fertility, pest and disease management. Mixed cropping is often seen as a tool enabling more efficient use of space, nutrients and water, and as a result higher overall harvests are realized. Another approach to improve overall production is to intensify production. integration of animal husbandry in the farm would result in intensification, as it provides meat, milk and manure. If water is scarce, flexible sprinklers or drip irrigation might be a good strategic investment. Final production can also be improved by reducing losses during crop growth, harvest and in the postharvest process.

iii. Enhancing the value of farm output

In order to increase the market value of the farm products, farmers can adopt different strategies such as:

- Adopting more profitable enterprises like vegetable production, dairy, poultry or pig production, so long as feed and management requirements are suitable.
- Improving the quality of the products by investing in good storage facilities to reduce postharvest losses and benefit from off-season prices.
- Implementation of processing and storage activities may increase access to new and better markets. Simple on-farm processing activities like threshing, milling, fermenting, grading, cleaning, etc., if well implemented, can increase the value of farm products. If the farmer can make more investments, bigger processing activities might be started such as food processing making jams, dried fruits, pickles or processing milk into butter, cheese, ghee, yoghurt, etc.
- Specific certification such as organic or fair trade certification, can give higher prices, especially on export markets.
- The type of market where the produce is being sold will influence the price. In many cases, farmers get exploited by middle men who pay unfair prices. If this is the case, direct marketing of products can be an option. To sell to big wholesalers, a regular supply of items is needed. A single farmer may not be able to provide a sufficient

quantity to the wholesaler. Therefore, forming or joining an out grower producer scheme may be a good option to access a better market and gain more power in price negotiations with traders.

iv. Reducing expenses where possible

Ecological farming aims at closing nutrient and energy cycles and making best use of farm-own resources for highest possible self-sufficiency. Ecological farms thus tend to be of low external input agricultural system. This approach includes:

- Using locally available plants to prepare own botanical pesticides.
- Producing and multiplying own crop seeds, seedlings and other planting materials.
- Using locally available sources of manures, including waste from local agricultural processing plants, and keeping own animals for manure and other benefits. Use of kitchen waste, pruning from trees and hedges as either compost or mulching materials, will also increase soil fertility in the farm.
- Growing own food for the farm family needs and fodder for the animals.
- Sharing equipment and machines with neighbours or as a farmers group where the initial cost of buying the equipment can be obtained through a group loan.
- Using locally available materials for construction of buildings and farm structures.
- Developing labour-saving production methods, such as growing cover crops to reduce amount of labour for weeding

f. Developing a schedule of implementation-

The plan should also indicate a timeframe when the different activities will be conducted. This should be done in the sequence indicating which activities will be done first and last.

g. Responsibility bearing- This involves planning and assigning the persons/individuals to be in-charge of each activity and the labour requirement. The persons indicated should have the knowledge or ability to perform the activity or should be properly trained to understand the task he/she is responsible for. A

manager must accept the responsibility after making decisions.

h. Developing a budget plan based on resources needed-

The costs associated with the planned activities and any other resources needed like labour, or machines should be identified. It should be indicated whether these materials needed will be purchased, shared or hired. The farm plan should be made simple for the farmer to understand and implement. If a detailed plan is needed (e.g. for borrowing money), then you should seek assistance from an adviser for a more detailed business plan. Further information is also available in the Marketing and Trade module).

i. Implementing activities-This is concerned with collect timing of operations, purchase of inputs and supply of resources according to the plan.

j. Cyclical planning and monitoring of farm activities-

The farmer as the manager of the farm enterprise holds the vision of the farm (i.e. what the farm should become in future).

Cyclical planning is a continuous process performed to ensure that the farm is guided from 'what it is' to 'what I/we want it to be'.

This is to ensure accurate performance against set goals and objectives

Roles /functions of a farmer as a farm manager

- Objective setting –such as profit maximization, increased farm production to feed the family, and sell excess for cash or to produce for local or export market
- Farm planning- this is planning for production such as how much to produce, how to produce, when to produce etc also financial planning such as source of finance, how much finance is required and the mode of repayment. This role also includes:
 - ✓ Planning for market e.g. When and where to market
 - ✓ Staggering of production to coincide with high market prices
 - ✓ Planning for employment-permanent or casual, when to employ, number of employees e.t.c

- ✓ evaluating and deciding on alternative production methods
- Implementation and monitoring-Involves execution of the plan and monitoring the whole business with the aim of effecting necessary changes. This includes labour management interms of:
 - ✓ Terms of employment e.g. permanent, temporally, or casual
 - ✓ Rates of payment e.g. monthly weekly etc
 - ✓ Rewards and incentives i.e. salary/ wage increase
 - ✓ Working conditions- provision of protective clothing, insurance etc

3. Farm records and record keeping

Farm records are documents that a farmer maintains daily or over a given time period to assist in the assessment of the progress of his various farm enterprises

No farmer or indeed a business person; however good his/ her memories can keep all the details of the business in the mind. Those who try to do so are poor in management. Successful farmers say that one of the secrets of good management is to have a record keeping system so that there is no need to remember details.”

For proper monitoring of the farm plan, record keeping is very important. For certified organic farms and those under conversion, record keeping is compulsory. Specifically, records are needed related to the following areas:

- > Sources and uses of money on the farm
 - All quantities of inputs used on the farm and the quantities of harvests

Records can be kept either per plot or inform of a farm diary to record daily activities on the entire farm. Whichever documents are used, it is recommended to record as much detail as possible.

Farming is a business and involves many activities, the farmer must therefore keep neat concise, clear and complete record so as not to

forget the many things he has done or he ought to do.

To be of use, farm records must be true account of what has happened interms of amounts, weight measurements and dates, not guesswork or estimates. Such true records will be useful to the farmer in the following ways

- a. show the farmer whether the farming business is operating at a profit or loss
- b. show the farmer the physical performance of different enterprises from year to year ,hence any progress made
- c. farm records will help the farmer to draw farm plans and layout interms of crop rotation, selecting farm enterprises and formulating production policies /practices
- d. Farm records will enable the farmer to compare his /her production with those of other farmers or known standards, so that he will know whether he is operating below or above others. This should help him to adjust his production upwards
- e. they help the farmer to plan and budget for various enterprises
- f. financial records will help the farmer in
 - budgeting his operations
 - applying for loans from financial institutions
 - evaluating farm business so as to be taxed fairly or to get fair prices when he wants to sell some items or the whole farm
- g. Farm records will help in solving disputes i.e. in partnership property when it comes to sharing of profits or losses made.
- h. Records kept over a period of time will give the history of individual enterprises and the whole farm in general

Farm records provide a major tool for sound business management because the records monitor the essence of the business, if a business is to survive and thrive it needs to be monitored and record are one of the most effective ways of doing this.

Studies in Kenya have shown that only 15 of small scale farmers keep farm records yet issues of evaluation of land, capital items, inputs, labour etc all points to it being a welfare activity.

In developed countries, agriculture has developed in to real business and as much details records of resource use and production as well as accounting statements are required by law

In Kenya, some medium scale farmers and large scale farms actually keep records. To succeed in any sort of business you do not only need to work hard but you also need to have management skills and one of the tools of a good manager is record keeping .the other skills are accounting, budgeting, economic principles and peoples skills

Farm records allow the farmer to measure efficiency in the use of the factors of production e.g. land, labour and capital

Problems faced by small scale farmers in record keeping

Only a certain % of Kenyan small scale farmers actually keep records, medium and large scale farmers tend to keep records although not as good as they should.

The reasons as to why farmers find it hard to keep records include

- illiteracy and low level of education are quite common in the rural areas which exclude any possibility of meaningful record keeping
- The majority of small scale farmers farm for subsistence and sell any extra. they do not do farming as a business but as a way of life which does not formal records
- even literate farmers often lack training in book keeping , therefore they lack confidence in keeping records
- In Kenya farmers are not required by law to keep records as is the case in developed countries. presumably if they are required by law to keep records most of them would
- competent book keeping requires a lot of time and effort which might be considerably

be put into more profitable use such formal employment or self employment

- few farmers do not wish to know whether they are making a loss or profit
- in some cases issues of privacy may influence book keeping among those who wish to keep their transaction private

Farm production and statistical records

Total production from a farm does not show how efficient a farm is, to estimate efficiency both production and financial records are required.

Production records show the performance of crop and livestock enterprises while statistical records pertain to the efficiency in the use of inputs such as labour, fed, fertilizer etc.

Farmers can keep many different types of records as the situation requires e.g. Crop records, livestock records, labour records etc

The details required are determined by the use of the records and because there is a cost involved farmers should minimize this as much as possible. If records are properly kept they can generate considerable information on production and resource use efficiency. The records are also useful in farm accounts

Types of production and statistical records

a. crop production records

These will show the various crops the farmer is growing and the total area under each crop, field operation, usually shown per field on the operation card

Examples include; farm map, soil record, yield records, previous crop records, pest control records rainfall records etc

b. livestock production records

Different types of animal production records are kept depending on the type of animals.

Some animals /livestock production enterprises involve more operations and hence more records than others

Examples are

should still be aiming for a better return than you would wish to achieve.

- Farm workers will be looking for realistic rewards for their efforts, career opportunities and an environment in which they are happy to work.
- Customers will be looking for a product or service which fulfils need and which represents good value for money.

A business plan is a complete description of a business and its plans for the next one to three years. It explains what the business does (or will do if it's for a new business); it suggests who will buy the product or service and why; and, it provides financial forecasts demonstrating overall viability, indicates the finance available and explain the financial requirements.

A business plan is a written document that describes in details a proposed business and its purpose. It also shows the current business status, expected needs and projected results of a new or existing business and it shows a clear picture of what the business is, where it is going and how the entrepreneur proposes to get there.

The business plan should be presented in a form that can be quickly and easily understood. The main part of a business plan normally needs no more than eight to ten pages supported, if necessary, with more detail in appendices. The plan should be manageable, and form a working document in which you can find the management information you need.

A business plan is an analysis of the production, market and financial aspects of the proposed enterprise. It consists of:

- Description of the proposed production site
- A Marketing plan/strategy
- Description of production techniques/strategy
- Financial analysis of the proposed venture

Importance of a business plan

- A roadmap for business success- it provides a farmer with answers to such questions: where am I going, how do I get there, what problems and opportunities I may run into and how will I deal with them
- Ensures effective use of available limited resources to avoid wastage and inefficiency
- Acts as a communication tool to consider such as financial sources
- Ana operation tool guiding the business towards success.

Business plan contents/elements

a) Cover page

Contains the name of the business, name(s) of the owner(s), the person or organisation to which the business plan is to be presented and the date of presentation

b) Table of contents

Shows the reader of the plan where he can directly get certain item within the plan without necessarily going through the entire document

c) Executive summary

The executive summary is a synopsis of the key points of the farmer entire business plan. It forms a short and brief description of the business and contains all the major components in short statements. Its purpose is to explain the basics of your business in a way that it informs and interests the reader since it is the first information the reader will encounter. Although the executive summary is the first section that people will read, it should probably be written last.

It should explain how the purpose will be achieved and why the farmer/business owner is the person to make it happen.. If, after reading the executive summary, an investor or manager understands what the business is about and is keen to know more, it has done its job.

d) Business Description

This contains a comprehensive description of the business. It shows

- Introduction: type of business planed, whether or not the business has started,

explain who owns it how it will be run, what was the trigger to start the farm business and why the farmer thinks it will succeed..

- **Products and services:** Describe the products /services intended for production and sale, Explain why customers will want to buy the product or services. What needs does it fulfill? Its uniqueness in quality and value to the customer, the type of opportunity, success potential, growth potential and its uniqueness. Its benefits which might include, for example, ease of use, comfort, safety, economy, flexibility, taste, etc. Remember that the customer buys the benefits but you pay for the features.
- **Goals and objectives** This section should also briefly describe the purpose and goals of the business.

e) The market segment

Define carefully who you perceive to be your customer groups or niche markets. Your market research may have suggested that you aim your sales at a precisely defined target market or segment.

The farmer needs to demonstrate that a market exists. What is the overall size of the market? Estimate likely demand for your product or service in the short and long-term and justify this estimate. It is on the basis of such information that you will estimate your sales turnover.

This is divided into two parts;

- **Market Research and analysis:** it should describe the target market: i.e who the customers are, the size and its trends, the existing and possible competition
- **Marketing strategy:** this part should describe the methods that will be used to market the product, price of the product, make sales, advertise and promote the

product and also the distributing channels that will be used.

The purpose of your business in the summary or in the business section should be translated into marketing objectives and goals which will support its realization. Objectives should be quantifiable, measurable, challenging and achievable. Typical objectives might be profitability, sales growth, diversification and improvement in market share.

i. Production segment

This contains location of the business and its justification, needs of the production process such as equipment and machinery and plans for repairs and maintenance, raw materials suppliers and labour requirement and other production facilities such as premises. It also describes the production process and a clear estimate of the production costs.

ii. Management segment

Outlines key personnel that will be required to manage the business and their qualifications, the number of employees that will be needed and what each will do, their salaries and benefits. Consultants or specialists that may be needed and why? i.e their contributions to the business and lastly the support staff and their services. Here it may be desirable to provide an organisational chart with the entrepreneur at the top.

iii. Critical business risks

This section contains possible problems or risks that may face the business in the course of its operation, their financial implication or costs and how you intend to solve or control them

iv. Financial segment

This contains realistic financial projections/forecast. It may be done with assistance from an accountant. It should consist of start-up costs, expenses per month for at least the next three years and the expected income, the break even point, fixed and working capital requirements such as cash stock, overheads, cashflow needs and projections and sale forecasts. The total financial needs, potential funding

sources and how money from lenders will be used and how the loans will be secured if applicable. Lastly, include the income statement and the balance sheet. Carefully prepared financial statement represents the actual achievement expected from the business. It also acts as a standard tool for managing and controlling the business.

v. Production schedule

This contains the timetable of events in the business plan such as timing of the

accomplishment of the various business objectives. It should show the deadlines for each activity to facilitate monitoring when the business is in progress.

Example

Month..... Year			
Activity	Start date	Finish date	Remarks

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CHAPTER 6: SOIL AND WATER MANAGEMENT

1. Introduction.

‘Soil’ is the mantle (or layer) on the land surface that acts as a medium for plant growth. It is developed through continuous action of weathering depending on environmental factors. Soil formation is largely governed by five major factors: climate (e.g. rainfall, temperature, and wind), relief or topography of the area (i.e. landscape position), living organisms (vegetation and microorganisms), nature of parent material (type of rocks and minerals from which soil is derived) and time.

The basic components of soil are minerals, organic matter, water and air. Ideal soil (ideal for the growth of most plants) consists of approximately 45 % minerals, 25 % water, 25 % air, and 5 % organic matter. In reality, these percentages of the four components vary tremendously depending on numerous factors such as climate, water supply, cultivation practices, and soil type. Soil air and water are found in the pore spaces between the solid soil particles. The ratio of air filled pore space to water-filled pore space often changes seasonally, weekly, and even daily, depending on water additions through precipitation, through flow, groundwater discharge and flooding. The volume of the pore space itself can be altered, one way or the other, by several processes. Organic matter content is usually much lower than 5 % in most soils where it is not properly managed.

Mineral portion

The mineral portion of soil is divided into three particle-size classes: sand, silt, and clay. The sand, silt, and clay are collectively referred to as the fine earth fraction of soil. They are less than 2 mm in diameter. Larger soil particles are referred to as rock fragments and have their own size classes (pebbles, cobbles, and boulders). The relative proportion of sand, silt, or clay in a soil is known as soil texture.

Soil texture has an important role in nutrient management because it influences nutrient and water retention. For instance, finer textured soils

tend to have greater ability to store soil nutrients. Soils with the finest texture are called clay soils, while soils with the coarsest texture are called sands. However, a soil that has a relatively even mixture of sand, silt and clay, and exhibits the properties from each, is called a loam.

Soil water

All nutrients in the soil that are provided to the plants come from water held in the soil. In a critical way, water determines the potential for realized soil fertility and plant nutrition. Only a moderate amount of soil water is needed to allow for soil aeration. If there is too much water in the soil and if it remains for many days – meaning the soil is waterlogged – the soil becomes depleted in oxygen. Under these conditions, plant nutrients will not be available to the plants, and most of the beneficial soil microorganisms will not survive. Most plants will die under such conditions, with only a few exceptions such as rice and yams.

The main functions of water in the soil are:

- Promotes many physical and biological activities of soil
- Acts as a solvent and carrier of nutrients
- Acts as an agent in photosynthesis process
- Acts as a nutrient itself
- Maintains turgidity of plants
- Acts as an agent in weathering of rocks and minerals.

Soil air

Oxygen is essential for all biological processes occurring in the soil. It is provided to microorganisms and plant roots through larger and smaller spaces in the soil.

Soil organic matter

The organic matter component of soil, known in short as soil organic matter, can be divided into three general pools: living biomass of microorganisms, fresh and partially decomposed residues, and humus. Humus is the well-

decomposed organic matter and highly stable organic material.

Organic matter is mainly present in the top layer of the soil, which is subject to a continuous transformation process. Soil organic matter that is decomposed by soil organisms can recombine with mineral soil particles to form very stable humus structures, which can remain in the soil for many years. This long-term soil organic matter or humus contributes a lot to improve the soil's structure. Organic matter constitutes from 1 to 6 % of the topsoil weight of most upland soils. Soils with more than 12 to 18 % organic carbon (approximately 20 to 30 % organic matter) are called organic soils.

There are numerous benefits to having a relatively high stable organic matter level in an agricultural soil. These benefits can be grouped into three categories:

- **Physical benefits:** Soil organic matter enhances aggregate stability, improves water infiltration and soil aeration, reduces runoff; improves water holding capacity; reduces the stickiness of clay soils making them easier to till; reduces surface crusting, and facilitates seedbed preparation.
- **Chemical benefits:** Soil organic matter increases the ability of the soil to hold onto and supply over time essential nutrients such as calcium, magnesium and potassium – also known as Cation Exchange Capacity (CEC); it improves the ability of a soil to resist pH change this is also known as buffering effect capacity; accelerates decomposition of soil minerals over time, making the nutrients in the minerals available for plant uptake.
- **Biological benefits:** Soil organic matter provides food for living organisms in the soil; it enhances soil microbial biodiversity and activity, which can help in the suppression of crop diseases and pests; and enhances pore space through the actions of soil microorganisms. This helps to increase infiltration and reduce runoff.

Soil organisms and soil microorganisms

Soil is also the home for many organisms, some of which are visible to the naked eye like earthworms and termites. Others are tiny and can only be seen under a magnifying glass like bacteria. They are called microorganisms. Among the most important soil organisms are the earthworms and termites.

Most farmers are aware that the presence of earthworms is a sign of fertile soil. Earthworms fulfill several crucial functions: First, they accelerate the decomposition of plant material on the soil surface by removing dead plant material from the soil surface. During the digestion of organic material, they mix organic and mineral soil particles and build stable crumbs in their excrements, which help improve the soil structure. Earthworm excrements contain 5 times more nitrogen, 7 times more phosphate, 11 times more potash and 2 times more magnesia and calcium than normal earth. The tunnels created by earthworms promote infiltration and drainage of rainwater and thus contribute to prevention of soil erosion and water logging. Earthworms need sufficient supply of biomass, moderate temperatures and sufficient humidity and air. That's why they are very fond of mulching.

Frequent tillage and pesticides, on the other hand, decrease the number of earthworms in the soil. Termites due to their high activity and biomass can also be considered as almost always positive for soil structure and soil properties. In some cases, especially in the Sahel zone of Africa, termites are artificially introduced in order to degrade fine wood matter to produce compost to use as fertilizer for agriculture.

The most important microorganisms are bacteria, fungi, algae and protozoa. Soil bacteria such as Rhizobium bacteria help some plants to fix nitrogen from the air. Soil fungi constitute the major part of microbial biomass. An example of soil fungi is the mycorrhizae. Mycorrhizae grow in symbiosis (a close mutually beneficial relationship) with about 90 % of all plant roots.

The plant roots provide sugar for the growth of the fungi. In reverse, the mycorrhizae explore the soil and bring back water as well as nutrients such as phosphate, zinc and copper that are not easily available to plants. Mycorrhizae also dissolve minerals such as phosphorus, and carry them to the plant, make soil aggregates more stable thus improving soil structure, and take plant carbon from the air and deposit into soil organic matter and stable soil aggregates.

Incorporation of biomass into the soil, maintenance of a ground cover, mixed cropping, and reduced use of chemicals encourages build up of soil organisms.

In organic and sustainable cropping systems, the soil life is the engine of soil fertility and crop production, as well as the guardian of long term soil health.

Soil structure

Soil structure refers to the arrangement of soil particles with resultant formation of big and small pores between soil aggregates. Soil structure influences movement of water into and through the soil, the degree of aeration, the ability of the soil to resist soil erosion and crop roots to grow through the soil profile. Small pores are good in preserving moisture, while the larger ones allow a fast infiltration of rain or irrigation water and help to drain the soil and ensure aeration. Soil material fits and binds together in different ways. In some soils the bonding is very weak, in others very strong. The size of aggregates in some soils is very fine, whilst in others aggregates are coarse and large.

In some soils the aggregates are dense containing few pores, in others they are quite open with plenty pores. In soils with good structure, mineral particles and soil organic matter form stable aggregates. This process is supported by soil organisms such as earthworms, bacteria and fungi. The soil organisms excrete substances that act as cementing agents and bind the particles together. Fungi have filaments, called hyphae, which extend into the soil and tie soil particles together. Organic

matter works as a kind of glue, helping the soil particles to stick together. This makes it clear that soil structure can be improved by supplying organic matter and by enhancing the biological activity of the soil. Whereas incorrect soil management practices such as tilling the soil in wet conditions cause compaction and may damage the structure of the soil. Compacted layers, plough pans, surface crusting and root restriction are indicators of damaged soil structure

2. Causes and effects of land degradation

Land degradation is a process that lowers the current and /or potential capability of land to produce goods such as crops, livestock, and timber or to produce services such as unpolluted water. Continued deterioration of land may lead to permanent decrease of its biological potential and a deterioration of living conditions for the inhabitants. Depletion of nutrients and soil organic matter and erosion are the principal forms of land degradation. Producing crops without compensating the nutrient losses by removing plants also leads to land degradation.

There are many causes of land degradation but for the main causes are

- a. Soil erosion (by water and wind)
- b. Fertility degradation- loss of plant nutrients, chemical, Physical and biological degradation
- c. Degradation of vegetative cover
- d. Degradation of water resources

a. Soil erosion:

Soil erosion describes the process by which soil particles are carried away by water or wind. Soil erosion can lead to un-productivity of the respective soil and, thus, render the soil unusable for agricultural production. Erosion is strongly related to human activity

The main impact of soil erosion is the reduction in soil quality which results from the loss of the nutrient-rich and fertile upper layers of the soil, and the reduced water-holding capacity of many eroded soils. Therefore soil erosion is one of the

most serious threats to soil fertility. Even low erosion rates which are almost invisible can over the years have a severe impact on soils. It is therefore of vital importance to protect the soil from erosion. Especially organic farming fully depends on maintaining the natural fertility of the soil.

Soil erosion by water:

Soil erosion by water results from two main physical processes: detachment and transportation. The rate and magnitude of soil erosion by water is controlled by the following factors

- **Rainfall Intensity and Runoff:**

Rainfall erosivity is the potential of rainfall to cause erosion and is the driving force for most erosion processes. The impact of raindrops on the soil surface can break down soil aggregates and disperse the aggregate material. Lighter aggregate materials such as very fine sand, silt, clay and organic matter can be easily removed by the raindrop splash and runoff water; greater raindrop energy or runoff amounts might be required to move the larger sand and gravel particles. Runoff can occur whenever there is excess water on a slope that cannot be absorbed into the soil or trapped on the surface. The amount of runoff can be increased if infiltration is reduced due to soil compaction, crusting or freezing. Runoff from the agricultural land may be greatest during spring months when the soils are usually saturated, snow is melting and vegetative cover is minimal. Gully and rill erosion are the dominant forms of water erosion. They provide flow paths for subsequent flows, and the gullies or rills are in turn eroded further. This process leads to the self-organized formation of networks of erosional channels.

- **Soil erodibility**

This is an estimate of the ability of soils to resist erosion, based on the physical characteristics of each soil. Generally, soils with faster infiltration rates, higher levels of organic matter and improved soil structure have a greater resistance to erosion. Sand, sandy loam and loam textured soils tend to be less erodible than silt, very fine sand, and certain clay textured soils.

- **Slope Gradient and Length:**

Naturally the steeper the land slope is, the greater the amount of soil loss from erosion by water. Soil erosion by water also increases as the slope length increases due to the greater accumulation of runoff.

- **Vegetation:**

Plant and residue cover protects the soil from raindrop impact and splash, tends to slow down the movement of surface runoff and allows excess surface water to infiltrate.

Soil erosion by wind

Soil erosion by wind can cause much damage to soils, especially in the arid and semi arid areas. Wind erosion is accelerated when the soil is dry, weakly aggregated or less cohesive and bare.

The rate and magnitude of soil erosion by wind is controlled by the following factors

- **Erodibility of Soil:**

This is related primarily to soil aggregation. A well aggregated soil has clods that are too large to be transported by wind. Soils with poor surface structure (poorly aggregated) are more prone to wind erosion than soils with good structure. Soils which have a high proportion of fine sand and silt sized particles are particularly prone to soil erosion. Very fine particles can be suspended by the wind and then transported great distances. Fine and medium size particles can be lifted and deposited, while coarse particles can be blown along the surface (commonly known as the siltation effect)

- **Soil Surface Roughness:**

Rough surfaces reduce wind erosion by trapping soil particles and reducing wind velocity. Surface roughness can be increased by tillage but excess tillage can contribute to soil structure breakdown and increased erosion

- **Climate:**

Important climate factors include: wind frequency, wind velocity and wetness of soil during high wind periods. The speed and duration of the wind have direct relationship to the extent of soil erosion. Soil moisture levels can be very low at

the surface during periods of drought, thus releasing the particles for transport by wind

- **Unsheltered Distance:**

The lack of windbreaks (trees, shrubs, residue, etc.) allows the wind to put soil particles into motion for greater distances thus increasing the abrasion and soil erosion. Knolls are usually exposed and suffer the most.

- **Vegetative Cover:**

The lack of permanent vegetation cover in certain locations has resulted in extensive erosion by wind. Loose, dry, bare soil is the most susceptible. The most effective vegetative cover for protection should include an adequate network of living windbreaks combined with good tillage, residue management, and crop selection.

b. Chemical deterioration

Chemical deterioration involves loss of nutrients or organic matter, salinisation, acidification, soil pollution, and fertility decline. The removal of nutrients reduces the capacity of soils to support plant growth and crop production and causes acidification.

Plants respond to nutrient depletion in different ways but deficiency of nitrogen is commonly shown by yellowing of leaves.

Soil pH is the level of acidic or alkalinity of soils. Plant have different pH level requirement for optimal growth.

Soil requirement for selected crops

Crop	Optimum pH
Tea	4.0-5.5
Cabbage	6.0-6.5
Bean	5.5-6.0
Citrus	5.5-6.5
Potatoes	4.5-7.0
Tomato	5.0-7.0
Banana	6.0-7.5
Papaya	6.0-6.5
Maize	5.5-7.0

Acidification,

In high rainfall areas, a free draining soil loses its base (such as calcium, magnesium, potassium and

sodium) through leaching which results to soils becoming more acidic and the pH drops.

Soil pH below 4 is extremely acidic limiting plant growth and microbial activities. Note that Tea is exceptional as it thrives well on very acids soils.

Salinity and alkalinity problems are common in arid and semi arid areas where rainfall is not adequate and frequent to leach excess salts down through the surface. In Kenya, approximately 40% of land surface has soils that are either saline, or sodic, or both saline and sodic

Very few plants are salt tolerant and can thrive under saline- sodic conditions. High sodium content in soils has a marked influence on the physical and chemical properties of soil. When sodic soils are wet, the clay particles disperse and structure collapses.

Indicators of acidification in soils:

- Deficiency symptoms of potassium, calcium, magnesium.
- Lack of nodulation on leguminous crops- eg beans
- Low levels o pH(< 4.0)
- Decrease in yield
- Some plants are good indicators- eg Tea

c. Physical deterioration

Physical degradation occurs as a result of sealing, compaction, reduction of aeration and reduced permeability. Lack of organic matter and high percentage of very fine sands and silt in soils are some of the factors contributing to surface sealing.

Soil crusting and compaction tend to increase runoff, decrease the infiltration of water into the soil, prevent or inhibit plant growth and leave the surface bare and subject to other forms of degradation. Severe crusting of the soil surface because of breakdown of soil aggregates can inhibit water entry into the soil and prevent seedling emergence (Land and Plant Nutrition Management Service, 2002).

Use of cover crops, manure, mulch, minimum tillage etc can minimize risks of physical degradation.

d. Biological degradation

Biological degradation usually occurs as a result of loss of organic matter in the soil. Decomposition of organic matter is a function of microbial activities. In high rainfall areas, mineralization of organic matter is not as high due to lower soil temperatures and the topsoil horizon is characterized by high to moderate levels of organic matter. However erosion of topsoil will clearly result in a loss of organic carbon, therefore a loss of food for soil micro-organisms. Mixing crop residue with the soil provides food for micro-organisms and the development of microbial populations to greater depth than if residues were left on the soil surface. This intern enhance nutrient recycling within the soil profile

Indicators of biological degradation of soils:

- Decrease or absence of earthworms, termites
- Soil colour becoming lighter as a result of decrease in organic matter
- Some of the indicators of physical degradation

3. Soil and Water conservation measures:

Certain conservation measures can reduce soil erosion. Soil / land management practices such as tillage and cropping practices, directly affect the overall soil erosion problem and solutions on a farm. When crop rotations or changing tillage practices are not enough to control erosion on a field, a combination of measures might be necessary. For example, contour plowing, strip cropping, or terracing may be considered.

Types of soil and water conservation measures:

- **Agonomic:** such as plant / soil cover, conservation farming methods, contour farming. Cropping practices such as early planting and mixed cropping which improve density and duration of plant cover have a major impact in reducing soil and ware losses.

- **Conservational tillage, Less to no tilling of soil and reduction of heavy machinery use**
Industrial agricultural operations use tilling (plowing) to create rows, loosen soil, and to remove weeds. Sustainable farms use no-till methods or minimize tilling in order to protect the soil. No-to-minimal till methods can reduce soil erosion and compaction, increase aeration (critical for root growth and function), and reduce loss of water and critical nutrients.
Sustainable producers limit (or eliminate) use of heavy machinery, which conserves non-renewable resources (e.g., oil) and can decrease soil compaction and erosion.

- **Vegetative:** such as planting barriers (vegetative strips), live fences, windbreaks.

Grass strips, hedge barriers and trash lines will reduce soil and water losses and lead to the gradual formation of terraces. There are a wide range of grass and hedge plants to suit different situations.

Agroforestry can take many forms such as planting trees or shrubs on the boundaries, in gullies, in woodlots and along terrace embankments.

- **Structural:** such as terraces, cut off drains, barriers.

4. Soil fertility management

Soil health is a critical component of sustainable ecological agriculture and comprises a number of different growing practices and principles. There is also some evidence that sustainably grown plants may be higher in vital macro- and micronutrients, resulting from increased soil health as a direct consequence of organic growing methods and sustainable practices.

Some of these practices are outlined below:

Organic Fertilizer Use

- Inorganic (commercial) fertilizers are synthetically created (or mined) for the purpose of adding nutrients plants need to grow to the soil. The practice of monocropping and the lack of crop rotation on industrial farms result in the greater need for soil augmentation with synthetic fertilizers. Commercial fertilizer use can impair soil health over time, resulting in the need for additional application of inorganic fertilizers. It may also cause soil acidification and soil contamination with heavy metals. In addition, commercial fertilizers are a primary sources of water pollution. The production of inorganic fertilizers also requires large quantities of fossil fuels.
- Alternatives to synthetic fertilizer use include compost (decomposed organic matter), animal manure, seaweed, and worm castings. Each of these products can help boost soil health through the introduction and maintenance of healthy soil organisms and micronutrients. Organic fertilizers increase soil biodiversity and have been shown to increase the uptake of nutrients by plants. There is also evidence that use of organic fertilizers improves the nutrient value of the plants themselves.

Among the many problems facing the agricultural sector is diminishing good agricultural land. Consequently, there is a need to intensify land use. However, this may not be sustainable through production based on the natural fertility of the of the soil type in Kenya. Increased output of agricultural products can only be achieved if nutrients removed from the fields with the harvests are continuously replaced. The result of high cost of external inputs, limited knowledge on soil fertility management, over exploitation of the soil is a diminished resilience of the soil system to provide a suitable medium for crop growth.

Soil Fertility is defined as the ability of soil to provide all essential nutrients in adequate

quantities and in the proper balance for the growth of plants independent of direct application of nutrients when other growth factors like light, temperature and water are favorable.

This ability does not depend on the nutrient content of the soil only, but on its efficiency in transforming nutrients within the farm's nutrient circle. In transformation of nutrients soil organisms play a key role. They break down biomass from crop residues, green manures and mulch and contribute to build up of soil organic matter, including humus, the soil's most important nutrient reservoir. They also play an essential role in transferring nutrients from the soil organic matter to the mineral stage, which is available to plants. Soil organisms also protect plants from disease and make the soil crumbly.

A fertile soil is easy to work, absorb rain water well, and is robust against siltation and erosion. It filters rain water and supplies us with clean drinking water. It neutralizes (buffers) acids, which pass through contaminated air to the soil surface, and decomposes pollutants such as pesticides rapidly. And last but not least a fertile soil is an efficient storage for nutrients and CO₂.

In this way a fertile soil prevents the eutrophication of rivers, lakes and oceans and contributes to the reduction of global warming. In the context of biological agriculture soil fertility is thus primarily the result of biological processes, not of chemical nutrients. A fertile soil is in active exchange with the plants, restructures itself and is capable of regeneration. The biological properties can be observed in the soil's conversion activity, in the presence and the visible traces of the organisms in it. The communities of microorganisms are robust and active at the right moment. In the self-regulating ecological equilibrium animals, plants and microorganisms all work for each other.

It is the responsibility of farmers to understand soil ecology to the point that they can create or restore the conditions for a robust balance in the

soil. If a soil does not regularly bring good yields, farmers should investigate the reasons for it.

Properties of a fertile soil

- A fertile soil is rich in nutrients necessary for basic plant nutrition (including nitrogen, phosphorus, potassium, calcium, magnesium and sulphur);
- A fertile soil contains sufficient micronutrients for plant nutrition (including boron, copper, iron, zinc, manganese, chlorine and molybdenum);
- A fertile soil contains an appropriate amount of soil organic matter;
- A fertile soil has a pH in a suitable range for crop production (between 6.0 and 6.8);
- A fertile soil has a crumbly structure;
- A fertile soil is biologically active;
- A fertile soil has good water retention and supply qualities.

Appropriate amount of plant nutrients

There are 16 essential nutrients that plants need in order to grow properly. Out of the 16 essential elements hydrogen, carbon and oxygen are obtained mainly from the air and from water .

The other essential elements come from the soil and are generally managed by the farmers. Some of these nutrients are required in large amount in the plant tissues and are called macro (major) nutrients. Others are required in small amount and are called micro (minor) nutrients.

Macronutrients include nitrogen (N), phosphorus (P) potassium (K), calcium (Ca), magnesium (Mg), and sulphur (S). Of these N, P and K are usually depleted from the soil first because plants need them in large amounts for their growth and survival, so they are known as primary nutrients. Ca, Mg and S are rarely limiting and are known as secondary nutrients.

Where soils are acidic lime is often added, which contains large amounts of calcium and magnesium. Sulphur is usually found in sufficient

amounts from the slowly decomposing soil organic matter.

The micronutrients are boron (B), copper (Cu), iron (Fe), chloride (Cl), manganese (Mn), molybdenum (Mo), and zinc (Zn). Recycling organic matter such as crop residues and tree leaves is an excellent way of providing micronutrients to growing plants

Plant roots require certain conditions to obtain nutrients from the soil:

- The soil must be sufficiently moist to allow the roots to take up and transport the nutrients. Sometimes supplying water to plants will eliminate nutrient deficiency symptoms.
- The pH of the soil must be within a certain range for nutrients to be releasable from the soil particles.
- The temperature of the soil must fall within a certain range for nutrient uptake to occur.
- The nutrients must be within the root zone in order for the roots to access them.

The optimum range of temperature, pH and moisture is different for different species of plants. Thus, nutrients may be physically present in the soil, but not available to plants. Some knowledge of soil pH, texture, and history can be very useful for predicting what nutrients may become deficient. On the other side, too much of any nutrient can be toxic to plants. This is most frequently evidenced by salt burn symptoms. These symptoms include marginal browning of leaves, separated from green leaf tissue by a slender yellow halo. The browning pattern, also called necrosis, begins at the tip and proceeds to the base of the leaf along the edge of the leaf.

Neutral soil pH

Soil pH, its acidity or alkalinity, is highly relevant to how readily available nutrients become in soil, known as solubility of nutrients.

In Kenya, about one-third of the soils are acidic or prone to acidity and another one-third is either saline or alkaline and both are difficult to manage. Plants differ in their sensitivity to a low or high pH level. Some plants can withstand or even prefer a somewhat low pH level, others a higher one. Soils with pH less than 6.5 and which respond to liming may be considered as acid soils. When potassium, calcium and magnesium leach from the soil, it becomes acidic. This may happen if there is a lot of rain (or irrigation water) that washes nutrients away, or if too much mineral nitrogen fertilizers are applied. In acid soils plant roots do not grow normally due to toxic hydrogen ions. Phosphorous gets immobilized and its availability is reduced.

Most of the activities of beneficial organisms like Azatobacter and nodule forming bacteria of legumes are adversely affected as acidity increases under acidic conditions, the bacteria fix less nitrogen and decompose less organic matter, which results in fewer available nutrients. Addition of lime or compost with high pH (8) will help to neutralize acidity and to increase the pH, so that the availability of nutrients will be increased. Alkaline soils are formed due to concentration of exchangeable sodium and high pH. Irrigated soil with poor drainage may lead to alkali soils.. Application of molasses or growing of green manure crops and their incorporation in the field can also help to correct an alkaline soil

Crumbly structure

Plant roots prefer soil with a crumbly structure, like well-made bread. Such soil is well-aerated and the plant roots are able to penetrate easily. This allows them to grow both wide and deep allowing them to access more nutrients to support good growth. Soil aggregation is also an important indicator of the workability of the soil. Soils that are well aggregated are said to have “good tilth”. A good soil structure also contributes to reduction of erosion of topsoil, as water infiltrates more easily into the soil and the aggregates resist to the raindrops.

High biological activity

Even if we cannot see most soil organisms doing their work, the majority of soil organisms are very important to the quality and fertility of soils. They contribute to the transformation of crop residues and organic fertilizers to soil organic matter, to the improvement of plant health by controlling pest and disease organisms and to helping release nutrients from mineral particles. High biological activity is an indicator of fertile soil. Most soil organisms prefer the same conditions as plant roots: humid conditions, moderate temperatures, air and organic material are best for them. Most are very sensitive to changes in soil moisture and temperature. Their activity is generally low when soils are dry, very wet or too hot. If the soil is compacted, dried out, baked by the sun, or is poor in organic matter, it becomes like a piece of concrete and soil organisms cannot do a good job. Even the bacteria, as tiny as they are, cannot work in a dead soil. Good air circulation within the soil is crucial for their development. Activity is highest in warm and moist soils when “food” is available

Challenges associated with mineral fertilizers

- The nutrients in mineral fertilizers are highly soluble, easily taken up by the plant, but also easily leached out of the soil (especially nitrogen). They have to be applied cautiously so as to not to end up polluting streams or groundwater, which causes health problems in humans. Nitrates found in well water, for instance, are known to cause methaemoglobinaemia, also known as ‘blue baby syndrome’, where the blood is short of oxygen.
- When plants receive nutrients in the form of mineral fertilizers through the soil water, they are forced to grow quickly, making them vulnerable to diseases and attractive to pests. On the other hand, when nutrients are supplied through biological activity from the decomposition process or humus, for instance, then the flux of nutrients (although water soluble) is slower and in more continuous supply compared to mineral fertilizers where nutrients are only available for a short period of time.

- Mineral fertilizers are salts that may help to neutralize alkalinity such as ammoniated fertilizer. In African acid, infertile, red soils in arid and semi-arid climates, however, ammoniated fertilizers contribute to acidity, increasing problems with plant nutrition
- Mineral fertilizers are very expensive for most farmers in Africa. Farmers who take out a loan to buy farm inputs depend on a good harvest to pay back the credit. Repayment becomes a problem when crops fail due to other reasons or when crop returns are low.
- Reliance on mineral fertilizers cannot halt the continued degradation of soils, because these fertilizers only address the mineral fraction of the soil and ignore, if used solely, the role and potential of soil organic matter and the need to implement other soil conservation measures to maintain soil fertility.

Sustainable Ecological Agriculture approach to soil fertility management

Intensively managed farming systems require good soil fertility management to ensure long term sustainability of own food production. That is why proper soil fertility management is of central importance in organic crop production and farming. Basically organic farmers approach soil fertility management by conserving and protecting their soils from sun, rain and wind, and feeding it with organic material in an appropriate way, so as to allow it to feed the plants in a balanced way. When the soil is fertile in the organic sense, it can produce good crop yields for several years.

The three-step approach

Organic soil fertility management can be seen as a three-step approach with a range of tools to manage soil fertility and plant nutrition.

Step 1: Soil and water conservation

The first step consists of conserving the soil, soil organic matter and soil water from loss. Applied measures aim at protecting the soil surface from being exposed to the sun and drying out, and from being carried away by wind or washed down by rain. The aim is to establish a stable and less

vulnerable soil as the foundation to managing its fertility.

This provides a good foundation for building fertile soil. Soil conservation can be achieved through the following practices:

- Preventing soil erosion by reducing the movement of water with contour ridges and bunds, grass strips and terraces, and application of mulch to the soil surface.
- Protecting the soil with mulch and cover crops.
- Harvesting water with pits and water catchments.
- Application of reduced tillage to minimize soil disturbance.

Step 2: Improvement of soil organic matter

The second step consists of improving organic matter content and enhancing biological activity in the soil. The aim here is to identify appropriate organic resources that can build an active soil with good structure which can hold water and supply plant nutrients.

These practices aim at enhancing the organic matter content of the soil as the basis of soil fertility and for efficient management of plant nutrients and water. The practices related to it include:

- Producing own compost or supplying compost or other organic materials from outside the farm supplies stable humus substances to the soil and thus improves its structure and water holding capacity contributing to improvement of soil organic matter content on a long term.
- Growing green manures to produce large quantities of fresh plant material, which are incorporated into the soil, feed the soil organisms and mineralize rapidly to provide nutrients to the crop that follows.
- Recycling of valuable animal manures for composting or fertilization of the crops. Soil fertility is best improved through combined implementation of the different practices. One practice alone may not be sufficient to maintain or even improve fertility of soils.

Step 3: Soil fertility supplements

The third step consists of supplementing the nutrient requirements as well as improving the growing conditions by applying some soil amendments. In situations of heavy nutrient depletion or un-favourable growing conditions such as extreme pH levels, there can be a great shortage of macro- and micronutrients. Specific measures may be necessary to speed up improvement of the growing conditions for plants. These supplementary measures include:

- Use of self-made liquid manures that are easily available to plants.
- Use of soil amendments such as lime to correct soil pH and microbial inoculations to enhance biological activity of the soil and nitrogen fixation in the soil.
- Use of irrigation to supplement water requirements.
- Use of commercial organic and selected mineral fertilizers to satisfy specific nutrient needs.

Each step of the three-step approach builds the foundation for the next one. The aim is to optimize steps 1 and 2 that encourage natural rejuvenation of the soil and to minimize application of foreign fertilizers, soil amendments and irrigation water (step 3).

Proper and efficient application of steps 1 and 2 saves on costs for fertilizers and other supplements and prevents possible negative impacts on the farm ecosystem.

Understandably, the application of the third step will only be fully effective, when methods of the other two steps are properly applied, for example where valuable topsoil is lost because of poor erosion control, soil amendments will get lost as well.

Ecological soil fertility management principally relies on natural sources and biological processes and seeks for a long-term improvement of soil fertility based on optimization of farm-own nutrient management. In some conditions though,

it may be necessary to supply organic materials from outside the farm to build up soil fertility and produce reasonable harvests in a short time.

In certified organic agriculture, mineral fertilizers shall be used as a supplement to biologically-based fertility methods only. Their use shall be justified by appropriate soil and leaf analysis. In certified organic agriculture only naturally occurring mineral fertilizers are allowed.

How soil loses fertility

- Soil erosion
- Poor tillage practices
- Insufficient organic matter and mining of the soil.
- Excess use of chemical fertilizers
- Leaching.
- Overgrazing
- Poor cropping systems

Note

- The biggest problem is not the soil directly but the people working on the soil. Soil must be used by good farmers to remain productive. The emphasis must always be on the people who care for the land, not directly on the land.
- A poverty ridden people pass their suffering to the soil” (Maher 1950) as quoted by (Biamah et al 2000)

The continued use of inorganic fertilizers without inputs of organic matter has led to declining yields because of other problems such as imbalance or deficit of certain nutrients, acidification of the soil or deterioration of soil structure. Inorganic fertilizers are also not readily available to farmers and are often not applied in the right amounts and apart from the high costs of inorganic fertilizers, determining the right type to use has been and continues to be a major problem

Nutrient sources

Organic nutrient sources include, farmyard manure, compost, Vermi compost, liquid manures, plant teas, plant residues, leguminous green manure, cover crops mulches, etc

- **Farm yard manure**

Farm yard manure- is the accumulation of animal droppings where animals are enclosed during the night or in a zero grazing unit. This can be enhanced by adding vegetative materials as beddings which helps to absorb and store the nitrogen rich animal urine. (Kimaru et al 2003)

Fresh manure should not be used directly in the soil because the free nitrogen it contains can be harmful to plants and likely to attract pests, diseases and cause weed proliferation.

Farmyard manure commonly describes a more or less decomposed mixture of livestock dung and urine (mostly from cattle) mixed with straw and litter, which was used as bedding material. It may also contain residues from the fodder fed to the cattle and decomposed household waste.

Farmyard manure is extremely valuable organic manure. Farmyard manure contains large amounts of nutrients. The availability of phosphorus and potassium from farmyard manure is similar to that of chemical fertilizers.

Chicken manure is rich in phosphorus. When dung and urine from cattle are mixed, they form a well-balanced source of nutrients for plants.

Many farmers still underestimate the value of animal manure. In many places, it is dried and burned for cooking or just not recognized as a source of nutrients and organic matter. By drying or burning farmyard manure, large quantities of organic matter and nutrients are lost from agricultural systems.

Appropriate recycling of nutrients on the farm, especially if it comes from a high-value source, is a principle of organic farming. Therefore, proper handling and use of animal manures are essential to ensure that the nutrients in the manure are

preserved and the risks of causing environmental pollution are minimized.

Most farmers do not own animals, and neither do they have access to animal manure. Growing animal feed and integrating livestock into the farm not only provides milk and or meat and other animal products, but also some animal manure. In areas with mixed crop-livestock farming systems manure is likely to be available to most households, although at varying levels.

Improving the value of animal manure

Farmers should optimize the use and effectiveness of animal manure. Rather than applying raw animal manure in the soil, farmers should be encouraged to compost the manure from cattle and other ruminants, while making liquid fertilizer from poultry manure, which is less suitable for composting due to its high moisture content.

Farmyard manure is ideally collected and stored for a while before use. When used fresh the manure can inhibit crop growth considerably. Fresh manure can result in a temporary nitrogen lock-up, as it is used by the microorganisms to decompose the fresh manure, and it also does not contribute to improving soil humus. Animal manure with a small amount of litter is best composted or mixed with plant material for composting. Manure with a high proportion of litter, however, is best stored under anaerobic conditions. Compression of manure slows down decomposition and prevents overheating and thus reduces loss of nutrients. Collection of farmyard manure is easiest if the animals are kept in stables.

For storage, the manure should be mixed with dry plant material such as straw, grass, crop residues or leaves to absorb the liquid. Straw that has been cut or mashed by spreading it out on a roadside can absorb more water than long straw.

The manure can either be stored next to the stable in covered heaps or pits. Or it is stored within the stable as bedding, provided it is covered with fresh bedding material. To minimize nutrient losses, the

farmyard manure should be protected from sun, wind and rain.

Ideally, a trench collects the liquid from the manure heap and the urine from the stable. A dam around the heap prevents uncontrolled in- and outflow of urine and water. Water-logging as well as drying out should be avoided. If white fungus appears (threads and white spots), the manure is too dry and should be dampened with water or urine. A yellow-green colour and/or bad smell are signs that the manure is too wet and not sufficiently aerated. If the manure shows a brown to black colour throughout the heap, the conditions are ideal. Storing manure in pits is particularly suitable for dry areas and dry seasons. Storage in pits reduces the risk of drying out and the need to water the pile.

However, there is greater risk of water-logging and more effort is required, as the pit needs to be dug out. For this method a 90 cm deep pit is dug with a slight slope at the bottom. The bottom is compressed and then first covered with straw.

The pit is filled with layers about 30 cm thick and each layer compressed and covered with a thin layer of earth. The pit is filled up until it stands about 30 cm above ground and then covered with 10 cm of soil.

The quality and value of manure can be improved by the following approaches:

- Proper design of the animal housing to facilitate easy and efficient collection of manures.
- Provision of adequate bedding material of straw or dry grass to capture as much excreta as possible. The more bedding is used the better.
- Composted animal manure proves to be more efficient on yield in acidic, sandy soils than when applied directly, even if nitrogen is lost in the composting process

- **Composting**

Compost is a common name used for plant and animal material (mainly animal manure) that has been fully decomposed in a targeted process

initialized and controlled by man. Compared with uncontrolled decomposition of organic material as it naturally occurs, decomposition in the composting process occurs at a faster rate, reaches higher temperatures and results in a product of higher quality.

Composting is a means of ensuring or improving long-term soil fertility, especially to smallholder farmers with no or little access to manures and fertilizers. Compost is more than a fertilizer. It is not just a nutrient source, but also acts on the structure of the soil and on its capacity to hold and provide nutrients and water. Its main value lies in its long-term effect on soil fertility.

Compost contributes to an increase of the organic matter content of the soil and thus to a better soil structure. It clearly enhances drought resistance of crops.

During the composting process diseases, pests and weed seeds are destroyed. Even viruses are destroyed, if a high temperature is reached. Thus, composting helps solve common problems associated to the management of plant residues. Compost also increases biological activity of the soil and its capacity to positively influence biological control of root rot diseases from fungi, bacteria and nematodes.

In the composting process nutrients are absorbed into the organic matter, microorganisms and humus. The humic substances are relatively resistant to microbial decomposition. Thus, the nutrients are released slowly and are not easily lost.

Compost has proven to be the best type of organic fertilizer in dry climates. It also increases the effect of even small amounts of manure.

Deficiencies of trace elements are less likely, when compost is applied, as compost contains trace elements as well. Compost also increases the availability of phosphorus to plants in soils rich in iron oxides. Due to its neutral pH, compost improves the availability of nutrients in acid soils.

Where soils tend to be water-logged, composting helps avoid nitrogen losses occurring from incorporation of green plant material under such conditions

The composting process

Properly made compost goes through three phases: the heating phase, the cooling phase and the maturing phase.

1. The heating phase. During the heating phase, within three days after setting up the compost heap, temperature in the center of the heap rises to about 60 to 70 °C. It usually stays at this level for two to three weeks. The high temperature is a result of the energy that is released during the decomposition of easily digestible materials by the bacteria. The warm temperature is typical and important for the composting process. The heat destroys diseases, pests, weed-roots and seeds and thus prevents their further propagation.

Due to the rapid development of their population, the oxygen demand of the bacteria is very high during this phase of the composting process. High temperatures in the heap indicate that oxygen supply is adequate. If temperature stays low or the compost develops an unpleasant odour, this can be an indication that the heap is compacted and oxygen supply is low.

Bacteria not only depend on oxygen, but also on humidity for their development. Due to the high biological activity and high evaporation, the humidity requirements are highest during the first phase of composting.

- The cooling phase.- After decomposition of the green plant material by the bacteria, the temperature in the compost heap declines slowly to 25 to 45 °C. When temperature declines, fungi settle and start the decomposition of straw, fibres and wooden material. As this decomposition process is slower, the temperature of the heap does not rise.
- The maturing phase. During the maturing phase, red compost worms and other soil organisms start to inhabit the compost heap. Nutrients are mineralised and humic acids

and antibiotics are built up. At the end of this phase the compost has lost about half of its original volume, has taken on a dark colour and the smell of fertile soil and is ready to use. Water requirements during this phase are low.

The longer the compost is stored, the more it will lose its quality as a fertilizer. Its capacity to improve soil structure, however, will increase

How to make compost

a. Selection of a suitable composting site

The composting process should be conducted in a place that is easy to access for easy transport of materials to the composting site and close to the fields where the compost is to be used after production, and next to a water source. A well drained and leveled ground minimizes the risk of sieving out of nutrients by runoff rainwater. Natural shade such as a tree or a built shade reduces evaporation.

An adjustable structure may allow its removal during rain. There should be an appropriate distance from short term crops such as vegetables to avoid the risk of contamination, especially if animal waste is used.

Operational parameters

Since composting is an exclusively biological process, all those factors which influence, whether directly or indirectly microbial metabolism affects the process:

(i) Composition of mass

Organic matter for composting is composed of solids, water and gas with a constant interchange among the three fractions. Solid matter consists of ash, inert material and bio-degradable organic matter containing water. The individual relationships among these components are extremely important for the evolution of the process and the quality of the end product.

(ii) Aeration of mass

It is obvious that the microorganisms must have a constant supply of fresh air to maintain their metabolic activities unaltered.

(iii) Temperature

Too often, high temperature has been considered a necessary condition for good composting. However, for rapid composting, high temperatures for long periods must be avoided.

(iv) Moisture

Moisture content and aeration are closely interrelated in terms of displacement of air in the inter spaces by water and promotion of aggregation and lowering of the structural strength of the material. Too little moisture arrests the biological process while too much of moisture interferes with aeration by clogging the pores.

(v) Carbon to Nitrogen ratio

High carbon to nitrogen ratio will slow decomposition and increase nitrogen loss.

(vi) PH level

Generally, organic matter with high range of pH range (3-11), can be composted. However, optimum values are between 5.5-8. High values of pH in the starting material in association with high temperature can cause a loss of nitrogen through volatilization of ammonia.

b. Materials and tools for compost production

Ideally composting plant material is a mixture of 50 % different fresh green material and 50 % of dry material. The rate of coarse material should not exceed 10 %.

If too much fresh material is used, aeration of the heap will be poor. As a result the heap will start to smell and nitrogen will be lost. If too much dry material is used, bacteria lack food and the composting process will not start. Larger quantities of dry material are thus best left in the field to protect the soil surface from drying out and being washed away.

As most crop residues are low in nitrogen, sources high in nitrogen such as leaves of green legume plants or prunings from leguminous trees or legume stalks may be used to insure sufficient nitrogen for the composting process. Also materials from shrubs such as tithonia, gliricidia, leucaena, sesbania, crotalaria and lantana leaves are good materials to use.

Whenever possible, plant materials should be composted together with animal manure. Addition of animal manure accelerates the composting process and results in compost with higher fertilizer value. Dung can be dissolved in or mixed with water and poured over the compost heap when preparing the compost. Urine and slurry, both rich in nitrogen, can encourage decomposition of dry material when poured over it. Ashes can be spread in thin layers between the other materials. Too much ash, however, can result in gaseous nitrogen losses.

Some earth or old compost can be used as well. Earth will adsorb escaping nitrogen well. Where soils have the tendency to fix phosphate, ground rock phosphate is best added to the compost, as it will be more readily available to the plants than if it is added to the soil directly

Lime can be added in small quantities, but is in general not necessary for the composting process.

Tools needed for composting include a hand hoe, machete (panga), stick pegs, spade or forked hoe, watering can, wheelbarrow, sharp stick or compost thermometer (to monitor the temperature changes in the compost heap). For watering, a watering can or a sprayer should be used rather than a bucket, as this allows the material to better soak up the water.

Materials that should not be used for composting include materials from diseased or pest infested plants or plants that have been sprayed with pesticides or herbicides, materials with hard prickles or thorns, which may hurt the persons handling the compost. Persistent perennial weeds should not be composted either. Instead they should be destroyed by spreading them out in the sun to dry, or even burning. The dried material or ashes can then be added to the compost heap. Non-organic materials such as metal or plastic, rubber, leather and textile materials cannot be composted

Compost making procedure

There are different methods for making compost based on different approaches and origins. They include the Indore and the Bangalore method, which were developed in India, the heating process/block method, the Chinese high temperature stack, the pit, trench, basket or the Boma composting. Each of these methods has advantages and disadvantages.

In the Bangalore method, the composting materials are mixed with urine, slurry or dung. The heap, once set up, is plastered with a layer of mud and is not turned. Due to the mud layer, the composting process becomes semi-anaerobic after a few weeks. The method is simple to use and needs little labour and water. It has fewer nutrient losses than the Indore-method, but may not destroy all diseases and needs more time to reach maturity.

In the Indore method the heap is turned twice. It is more labour intensive and needs more water than the Bangalore method, but has a shorter composting period. The materials go through an intensive heating phase. In dry climates composting is mainly practiced in pits to keep the compost humid and save on water and labour for maintaining ideal conditions.

Vermi-composting uses specially introduced earthworms for decomposition. It is a good technique for recycling food waste and crop residues from vegetable gardens in the proximity of the house. The composting period is longer as compared to other methods and varies between six and twelve weeks.

In this manual, we will look in details on heap/pile method ,Pit Method, Basket compost, vermi-composting and Bio fertilizers (Inoculants)

Pile/heap composting method

This method is suitable for areas with high rainfall.

Methodology

1. Select a location close to where you want to use compost. The place should be sheltered

from wind, rain, sun and runoff. A compost pile must not get either very dry or very wet.

2. Collect adequate quantities of the materials needed.
3. Measure a rectangular 120cm wide and 150cm or more long (depending on how much composting material you have). In rainy places, it is best to make compost in a pile above the ground. The width should enable to work with the compost without having to walk on it.
4. Dig out a shallow pit of the planned size of the compost heap. The more arid the climate, the deeper the pit is usually dug. Compost pits should, however, not be deeper than 50 cm to ensure aeration. If no pit is dug in a humid climate, loosen the ground where the compost heap will be, as the materials need close contact with the loose soil at the bottom. The topsoil obtained when digging the trench should be carefully put to one side beside the trench so that it can be used in the compost.
5. Woody materials should be chopped into pieces 5 to 10 cm in length or spread on a road or used as livestock bedding before composting to be bruised and increase its surface for better decomposition. Wet plant material such as seaweed or fresh grass should be wilted before mixing it with other material. Straw should be pre-soaked in water, if possible. Ideally dry material is thoroughly mixed with urine and animal dung.
6. Begin building compost by putting a bottom layer of rough material such as maize stalks and hedge cuttings to the pit. This layer should be about 30cm thick. Chop up any materials which are too long to improve the air circulation in the pile. Sprinkle some water on this layer.
7. Add a second layer of dry vegetation, hedge cuttings or grass. This layer should be about 15cm deep.
8. Put on a third layer of animal manure or biogas slurry. The manure contains microorganisms that are vital for decomposition.
9. Sprinkle some ash on this layer. The ashes contain valuable minerals e.g. potassium,

phosphorus, calcium and magnesium. The ashes also neutralize the acids produced during composition especially by animal manure.

10. The next layer should be of green materials 15-20cm deep. You should use green leaves from high protein leguminous trees like calliandra, leucena and sesbania. You can also use hedge cuttings of plants like tithonia.
11. Sprinkle on a little top soil or old compost. The top soil contains bacteria which are useful in the decomposition process.
12. Add more layers in turn starting with dry vegetation materials, then animal manure or biogas slurry followed by wood ash, green vegetation and top soil. Remember to sprinkle water on every layer. Built the pile up to 1.5m high. A well made pile has almost vertical sides and a flat top.
13. To complete the pile, cover it all over with a layer of top soil about 10cm thick. This layer prevents plant nutrients from escaping from the compost pile. Lastly cover the pile with dry vegetation such as banana leaves to reduce moisture loss through evaporation.
14. Pull the thermometer out from time to time to check the progress of the pile.
15. Sprinkle water on the pile occasionally about every 3 days depending on the weather.
16. After 2-3 weeks, turn the pile over and do not add any fresh material except water. Turning the pile is important because it mixes the different layers making the decomposition faster and more complete. The compost should be ready after 4 weeks. Check the temperature of the pile to make sure that, if the temperature is too high, the pile is still decomposing and the compost is not ready. Finished compost should have a freshly earthy smell and contains no grass, leaves or animal manure.
17. You can store compost by covering it with a layer of banana leaves or polyethylene (IIRR, 1984).

Pit composting method

The pit composting method conserves moisture, so it is useful in areas with low rainfall and a long dry season. Do not use it in wet areas as the compost may become waterlogged.

Methodology

- ❖ Dig a pit 1.2m wide and 0.6m deep and as long as you need, for the amount of materials you have.
- ❖ Built a pile in the pit using the same method as in the pile method.
- ❖ Add water if necessary.
- ❖ Push long poles into the pile to allow air to get into the layers beneath.
- ❖ Turn the pile every two weeks

You can produce a regular supply of compost by digging 3 pits side by side. Every two weeks, turn the compost from one pit to the next.

Compost usage

Well decomposed compost should be applied at a rate of 20t/ha or 8t/acre, or enough to barely cover the ground with a layer 1 cm thick. For potatoes, use one tin (about 20kgs) for about 2m of furrow. In double dug beds, apply 3 wheelbarrows of compost on 10m² of beds (IIRR, 1984).

Basket composting method

Where the piece of land to be put under a crop is small such as a kitchen garden or where there is not enough farm yard manure, then the basket method can be used to make compost.

Vermi-composting

Vermicompost (also called worm compost, vermicast, worm castings, worm humus or worm manure) is the end product of the break-down of organic matter by some species of earthworms. Vermicompost is a nutrient rich natural fertilizer and soil conditioner. The process of producing vermicompost is called vermi-compositing.

The earthworm species or composting worms most often used are red wigglers (*Eisenia foetida*) or red earthworms (*Lumbricus rubellis*).

Vermi-composting is the method where compost is prepared using specially introduced earthworms, Red Wigglers (*Lumbricus rubellus* or *Eisenia foetida*), as agents for decomposition. In contrast to ordinary composting, vermicomposting is

mainly based on the activity of worms and does not go through a heating phase.

Vermi-composting is a good technique for recycling food waste and crop residues from vegetable gardens in the proximity of the house. It creates small volumes of very rich manure. Though vermicompost is very good manure, it requires more investment (a tank and worms), labour and more permanent care compared to ordinary composting.

On the other hand, letting worms recycle farm or household waste saves time and labour input because no turning is required to keep the compost aerated. Red Wigglers reproduce quickly, adapt well to life in a confined environment, and compost food rapidly as they consume their weight in food per day. They are three to five inches in length, dark red in colour, and will tolerate temperatures from 12 to 30 degrees Celsius. They prefer to live in the dark and moist places, and about half a kilogram of Red Wigglers is needed to start a colony. The worms are very sensitive to fluctuations in moisture and temperature, however, and need a continuous supply of organic material for 'food'. To protect the worms from predators, a solid base is needed as they are also attacked by ants and termites.

Some experienced farmers use 'vermiwash', the liquid collected from the compost heap after sprinkling, as a leaf fertilizer and plant tonic. This can even help plants to get rid of pests, such as aphids and diseases. Vermicompost can also be used to make compost tea.

How to proceed for vermi-composting:

Build a brick and mortar enclosure with a concrete bottom, one or two chambers and proper water outlets. Convenient chamber size is 2 m x 1 m x 0.75 m. However, the size of the chambers should be determined according to the volume of the composting material.

Alternatively, a sizeable plastic or metal container or wooden boxes with a secure and removable lid to keep out predators and with ventilation holes on

the side walls and holes on the bottom to release excess moisture from the container, but small enough to keep out flies if possible. The 'four tank' or 'four chamber' method of chamber construction is also commonly used because it facilitates easy and continuous movement of earthworms from one chamber with fully composted matter to a fresh chamber.

Whatever container is used or built, it should be placed in a dark and damp place.

- A layer of good moist loamy soil (vermin bed) is placed at the bottom, about 15 to 20 cm thick above a thin layer (5 cm) of broken bricks and coarse sand.
- Earthworms are introduced (about 150) into the loamy soil, in which the worms will inhabit as their home.
- Then, a small quantity of fresh cattle dung is placed over the vermin bed.
- The compost pile is then layered to about 5 cm with dry leaves or preferably chopped hay/straw or agricultural waste biomass such as vegetable peels, leftover food, dead leaves and plants. Egg shells can also be broken into small pieces and added to the pile.
- For the next 30 days, materials are continuously added to the pit until it is full and is kept moist by watering it whenever necessary. Meat or fish scraps, greasy foods, dairy products or bones should not be added into the pile, as these will attract ants and rodents. The pile should be covered with porous material to keep off predators.

The compost should be ready within 60 to 90 days. The material will be moderately loose and not as heavy and with a dark brown colour.

In the two or four pit system, watering should be stopped in the first chamber so that worms will automatically move to another chamber where the required environment for the worms are maintained in a cyclical manner and harvesting can be done continuously in cycles.

To remove some of the compost, let the top of the heap dry out by discontinuing the watering for two to three days so that the worms move down to the cool base of the heap. Compost can then be removed and taken back to a fresh pile.

- **Natural liquid fertilizers**

Liquid fertilizers are helpful to overcome temporary nutrient shortages and to stimulate plant growth. They can be made of animal manure, compost or green plant material. Liquid manures are made from animal manure and compost tea from ripe compost while plant tea is made from nitrogen rich plant materials.

Liquid manures and plant tea are both a quick source of nitrogen, while compost tea is a nutritionally more balanced general fertilizer.

Liquid fertilizers are mostly used in vegetables, but can also be used for grains and other crops. Although all these liquid fertilizers may be made in the same way, manure tea is not generally recommended as foliar spray, but for application around the base of the plant. In case liquid manure is applied to the leaves in vegetable crops intended for raw consumption, a pre-harvest interval of at least 100 days is needed to avoid the risk of transferring human and animal pathogens.

Application of liquid fertilizers to the leaves is an interesting option in case of nutrient deficiencies, as plants absorb nutrients about 20 times faster through the leaves than through the roots. Besides promoting crop health and productivity, liquid manures that are applied to the leaves can also act as a good repellent for sucking insects, and may distort life cycles of some sap-sucking insects at the egg stage. They can also interfere with fungal spores.

Plant tea

Extra nitrogen for top dressing can be made locally from a special prepared liquid fertilizer termed plant tea (Kimaru et al., 2003). The plants used to make plant teas includes tithonia, Russian comfrey, lantana camara, and any other green leguminous plants.

To make plant tea, nutrient rich material is soaked in water for several days or weeks to undergo fermentation. Frequent stirring encourages microbial activity. The resulting liquid can either be used as a foliar fertilizer or be applied to the soil.

How to make plant tea:

- Chop the green plant materials like tithonia, velvet bean or any other sappy material, and put in a drum or any sizeable container until it is about three quarters full. Fill with water and keep it under shade or cover to prevent excessive evaporation.
- Stir every three days and the mixture will be ready to apply in about 15 days.
- Remove the remains of the plant material, sieve the mixture and dilute the tea with 2 parts water for every 1 part of tea. Apply the diluted mixture as a top dressing, giving between ½ to ¼ litres per plant for as long as needed. Cover the remaining undiluted mixture in a cool place

- **Manure tea/liquid manures**

Liquid manures/manure teas are useful for top dressing. Slurry of animal manure and urine from livestock shed makes good organic fertilizer as it is rich in nitrogen in the organic matter. Fresh manure from cattle, chicken, goats, sheep, rabbits or a mixture of any of these manures can be used.

The procedure for making good manure tea is as follows:

- Fill a bag with about 50 kg of manure and tie it securely with a rope. Hang the bag with the manure to a pole placed over a 200 litre capacity drum to allow it to suspend into the drum, then fill the drum with water.
- Cover the drum with a polythene sheet to prevent nitrogen from escaping and let it stand under shade.
- Stir the mixture in the drum every 3–5 days by partially lifting the bag in and out of water several times using the pole.
- After 2–3 weeks, the water will have turned dark and most of the nutrients will have been

dissolved into the water. The darker the colour, the more concentrated the mixture. It is then ready for use. Remove the bag with manure remains from the drum and the water solution is ready to dilute for use.

- Dilute the manure tea with 2 parts of water for every 1 part of tea. However, if the manure tea is very concentrated (very dark) use 3 parts of water to every 1 part of tea.
- Apply the manure tea to the crops, giving between 1/2 to 1/4 litres per plant starting 2–3 weeks after planting. Apply the manure tea around the stem and not on the leaves. Repeat the application every 3–4 weeks. Avoid application at full sunshine because of high risk of leaf burns and nutrient losses. Apply in the early morning or on cloudy days.

Compost tea

Compost tea is made from mixing already made compost with water forming a solution. Compost tea solution can be used unfiltered by applying it directly to the soil area around a plant.

If it is used as a foliar spray, it must be strained tea through a fine mesh cloth first and diluted with good quality well or rain water at a ratio of 10 parts water to 1 part tea. The color should be that of a weak tea. Addition of 1/8 tablespoon of vegetable oil or mild dish-washing liquid per 5 litres of water helps the spray adhere to the leaves. Application to the leaves should not be done during the heat of the day. Early morning or a cloudy day is best. Re-application is necessary after it rains

Commercial fertilizers for organic farming

Based on the IFOAM Norms for Organic Production and Processing application of commercial fertilisers (including lime) is allowed in certified organic agriculture with some restrictions.

While synthetic fertilizers such as urea are not permitted, use of commercial fertilizers should be justified by recommendations from soil or plant analysis. They must only be applied in their naturally occurring form and used in combination

with other techniques such as addition of suitable organic matter, green manures, crop rotations and nitrogen fixing plants.

There are different commercial fertilizers available on the market that are produced from natural substances and do not contain chemical residues. To most Kenyan farmers, however, commercial organic fertilizers are not easily accessible mainly due to economic and physical barriers. They also tend to be quite expensive.

Therefore, such fertilizers should only be used where using green manure and application of compost is not feasible or have not supplied sufficient nutrients for the crops, or where the crops show specific deficiency symptoms. In certified organic farming, it is the responsibility of the farmer to inquire from fellow organic farmers, trainers or certifying agents, whether a particular fertilizer is natural or not.

In many areas with the capacity to add lime in the case of acidic soils and sulphur in the case of alkaline soils, a conventional approach would be possible even if it did not represent the best solution. But considering constraints Kenyan farmers have to access fertilizers in general, large-scale liming or sulphuring appears to be an unsustainable approach to solve the problem.

Thus, as a general rule, commercial organic fertilizers should be mixed with other organic materials from the farm or composted together.

The East African Organic Product Standards (2007) permit the following fertilizers of mineral origin for East African organic farmers: basic slag, calcareous and magnesium amendments, limestone, gypsum, marl, maerl, chalk, sugar beet lime, calcium chloride, magnesium rock, kieserite and Epsom salt (magnesium sulphate), mineral potassium (such as sulphate of potash, muriate of potash, kainite, sylvanite, patentkali), natural phosphates, pulverized rock, stone meal, clay (such as bentonite, perlite, vermiculite, zeolite), sodium chloride, and sulphur. This list excludes Chilean nitrate.

Farmers are encouraged to consult with their extension agents or certifying agents before using any of these fertilizers as specific conditions might differ.

Commercial organic fertilizers are mostly by-products of agro-processing and food industrial waste. Examples include seed oil cakes (soybean, sunflower, neem, peanut), pelleted chicken manure, and agro-processing by-products such as brewery, fruit peels, coffee husks, wood shavings and dust, rice husks and plant ashes. Others include bone meal, feather meal, fish meal, horn and hoof meal, as well as commercially produced composts.

Microbial fertilizers and bio-innoculants

Microorganisms play an important role in the soil in providing nutrients to plants. Some microbes add nutrients to the soil through mineralisation. Others add nitrogen by fixing it from the atmosphere. These include *Rhizobium*, *Azospirillum*, and *Azotobacter*. Other microbes, such as Mycorrhizal fungi, help to supply plants with phosphorus. *Pseudomonas* species are a diverse group of bacteria that can use a wide range of compounds that plants give off when their roots leak or die. They are able to solubilize phosphorus and may help to suppress soil-borne plant diseases.

Legume inoculation means mixing legume seeds with a powder containing a special type of bacteria. This is done before planting the seed to make nodules on the roots of the legumes. The innoculant increases the amount of nitrogen fixed by the legume

Some farmers and companies may recommend the application of microorganisms to the soil to enhance decomposition processes and control diseases. These microbial fertilizers are usually sold as ready-to-use products for application as sprays or with irrigation water, or for mixing with compost. These products contain living microorganisms and need to be stored and applied cautiously. Microbial products should be used before their expiry date. It is recommended to find

out the effect of these products first by testing them on a small-scale and comparing results with the untreated plots.

Microbial fertilizers cannot substitute appropriate soil management practices on the farm. Most bacteria, fungi and other microorganism are naturally present in the soil and can be enhanced by proper application of compost.

Green Manures

Green manures are plants that are deliberately grown for the purpose of incorporating into the soil to improve soil fertility and organic matter. Legumes are the most commonly grown green manures but other plants that are not legumes such as tithonia may be used.

The green manure biomass supplies “organic food” to the soil and improve its nutrient content and thus its fertility. Cover crops and green manures are near synonyms. While the main purpose of growing cover crops is to cover the soil with a low vegetation cover to protect it from exposure to sun and rain as well as to suppress weeds, green manures are grown with the main purpose to build maximum biomass.

Green manures play a key role in organic farming. They are an invaluable source of food for soil organisms and thus of nutrients for the following crop. They are a farm-grown fertilizer and, therefore, are a cheap alternative to purchased fertilizers.

Green manures complement animal manures well and are of high value on farms where animal manure is scarce. Green manures can provide an incentive to abandon harmful traditional practices, such as burning crop residues or allowing animals to graze during the dry season, if their benefits are sufficiently large

In some regions farmers collect tree leaves and incorporate them into the soil of arable land. Though grain legumes, particularly cowpea, occur widely in traditional cropping systems, few farmers use the legumes for soil fertility management. Usually legumes are cultivated in

relatively intensive production systems only, where farmers are oriented to markets. Most Kenyan farmers, who grow crops for subsistence, grow legumes only if they provide valuable food.

Challenges and constraints related to the adoption of green manuring:

- The need of many farmers for an immediate economic product, such as grains, from any crop that is grown..
- Scarcity of cropland. Legumes are only grown in rotation, if the added benefit from them is very high, for example that it can be used as fodder or marketed.
- Water may be considered the limiting factor to growing a green manure crop in arid and semi-arid climates.
- Green manuring creates extra work.
- Especially in the beginning, seeds may not be easily available.

Benefits of green manures

- Recycling of nutrients. -Green manures contribute to recycling of nutrients.
- Production of biomass. Green manures supply the soil with great amounts of fresh biomass.
- Collection of nitrogen. -Legumes and other nitrogen fixing plants can provide considerable amounts of nitrogen to the soil and are particularly beneficial. In intercrops of legumes and cereal crops, cereals can take up some nitrogen from adjacent legumes.
- Prevention of soil erosion.-Green manures help to stop the soil from being carried away by wind and rain by providing a ground cover during their growth and a root system that holds the soil in place.
- Suppression of weeds.- Most green manure plants are fast growing and build a dense plant cover. This prevents weeds from growing beneath them and saves on time and labour which would otherwise be needed for weed control.
- High quality fodder-Some green manures can provide generous amounts of high protein fodder for livestock.

- No transportation. -Green manures are mostly grown in-field and usually do not require transportation, in contrast to compost or other organic fertilizers.

Integration of green manures into the cropping system

Many farmers do not grow green manures because they do not know which species to plant and how to integrate them in their cropping system. It is, therefore, important to plan where, when and how to plant which species in order to obtain good results.

There are several ways of integrating green manures into the farming system:

- Food and non-food legumes can be intercropped with cereals and tree crops
- Short duration non-food legumes can be grown towards the end of the cereal growing season using residual moisture.
- Legumes are grown as short-term rotational fallow.
- Long term green manures are grown for more than one season.
- legume trees are grown in an agroforestry system to provide nutrient rich plant material.

Other ways of maintaining soil fertility

- Soil and water conservation- The main objective of good water management is to improve the availability of water to plants through activities that enhance infiltration of rainwater, increases the soil water holding capacity and storage capacity, and minimizes evaporation from the soil and salinization.
- Crop rotation and Cropping systems- Crop rotation is the growing of different crops in a predetermined cycle on the same piece of land. Rotation of crops prevents pest build up and ensures balanced crop nutrient uptake according to the different plant nutritive requirement and rooting zones (Kimaru et al., 2000).
- Cropping systems such as intercropping, multiple cropping improves soil fertility where

legumes are used and it also allows for intensive land use (IIRR 1984).

- **Mulching** - is the covering of the soil with crop residues, dry grass and leaves, once rotten and decomposed mulch forms humus and adds to the organic matter in the soil. It also reduces the rate of water runoff minimizing soil erosion and improve infiltration
- **Conservation tillage** eg. Fertility trenches, double digging, zero tillage, etc- Conservation tillage helps in improving soil tilth that allows rapid infiltration of rainwater and storage of soil moisture in the root zone; it also incorporates fertilizer, green manure and animal manure to the soil while increasing root depth.

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CHAPTER 7: WATER HARVESTING

1. Introduction to water harvesting

Water harvesting refers to a range of methods of concentrating and storing rainwater run-off, including from roofs (roof harvesting), the ground (run-off harvesting) and from channel flow (floodwater harvesting).

In ground run off harvesting, the run-off from surfaces of roads and farmland is diverted into ponds and earth dams by soil bunds sloping towards the water reservoir

Rainwater harvesting is the practice of collecting the water produced during rainfall events before it has a chance to run off into a river or stream or soak into the ground and become groundwater.

Rainwater harvesting can be classified into two broad categories: land-based and roof-based.

- Land-based rainwater harvesting occurs when rainwater runoff from the land is collected in ponds, small impoundments, and earth dams by soil bunds sloping towards the water reservoir before it has a chance to reach a river or stream.
- Roof-based harvesting, on the other hand, involves collection of water from the roof catchment of buildings to storage equipments

Traditionally, rainwater harvesting systems have been used in homesteads as part of everyday life, to provide drinking water, domestic water, water for livestock, small irrigation and a way to replenish ground water levels.

Planning for rain water harvesting.

As you plan your rainwater collection and storage facilities, you need to keep two things in mind.

- The catchment and storage facilities must be designed so that they reduce potential sources of contamination.
- The catchment surface and storage tanks must be large enough to capture and store enough

rainwater to last you until the next time it rains. Otherwise, you will need to identify a supplemental source of water

Advantages of water harvesting.

- Water is available at household, time and energy is saved on collecting water.
- Simple technology and is easy to maintain.
- System is independent and can be managed at household level.
- Local material and skills can be used for construction of the system.
- Water collected can be kept in high quality and safe with simple precaution.

2. Water harvesting technologies

In Kenya, water is fast becoming a valuable commodity. With our growing population and the changing climate, our water resources are under increasing pressure. Much actual or potential water shortages can be relieved if rainwater harvesting is practiced more widely.

People collect and store rainwater in buckets, tanks, ponds and wells. This is commonly referred to as rainwater harvesting and has been practiced for centuries. Rainwater can be used for multiple purposes ranging from irrigating crops to washing, cooking and drinking

A homestead should preferably have the following variety of structures/technologies for harvesting rainwater to avoid water shortages during dry seasons:

- A roof catchment system for clean domestic water that consists of gutters fixed to a roof of galvanized roofing sheets which drains rainwater into a storage tank.

The size of a storage tank depends mainly on the financial capacity of the owner and to a lesser degree on the size of the roof and the volume of rainfall. Also the reliability to supply sufficient water during dry months should be considered if affordable.

- A pond or an earth dam for livestock can be excavated by hand or animal draught at a low place in the farm where rainwater flows, or accumulates, during rainy seasons. Ponds and dams can be built small initially and enlarged during the following dry seasons until they might supply water throughout the years.

In situ harvesting of rainwater in farm land increase the yield of crops, and what often determine whether there will be anything to harvest at all. Most farmers know and apply the techniques of soil conservation, which consist of:

- Contour planting in horizontal lines to prevent rainwater running off the land
- Contour grass and trash lines with grass and trees to stop rainwater running off
- Level bunds ridges which develop into terraces into which rainwater percolated
- Bench terraces developed slowly from level bunds ridges
- Micro basins with U and V shaped soil bunds for growing crops and trees
- Cutoff drains to discharge surplus rainwater run-off into gullies and streams
- Check dams made of stones and vegetation to prevent erosion in gullies

Any domestic rainwater harvesting system you use to produce drinking water for your home will consist of the following six basic components.

- Catchment surface: This catches the raindrops as they fall from the sky and then channels the water to a collection gutter.
- Gutters and downspouts: These channel water from the roof to the tanks that store untreated water.
- Leaf screens, first-flush diverters, and roof washers: These components remove debris and dust from the captured rainwater before it goes into the tank.
- Water storage tanks, or cisterns: These are receptacles that store the harvested rainwater until you are ready to treat and use it.
- Treatment/purification facilities: These are filters and disinfection equipment that remove contaminants from the untreated rainwater and make it safe to drink.

- Treated water storage containers- this includes storage containers for treated water safe for drinking.

Storage tank- storages tanks can be underground installed or above ground. If you install an above-ground storage tank, your contractor will help you design a pad that will assure that the tank remains level as the soil shrinks and swells. If you install a subsurface tank, your contractor will make sure that the tank is properly bedded so that it will be protected from soil movement, is constructed of material that is very corrosion-resistant, and is not installed in an area with a high water table.

You should not install your tank below the water table because it can shift or even float when it is empty.

We suggest that you use an above ground tank if possible because its more accessible and can be easily inspected, cleaned, and repaired.

However, above ground tanks are usually more susceptible to impact damage and may need to be fenced or otherwise protected. Also, remember that above ground tanks are exposed to sunlight and need to be protected from UV degradation, especially if you use plastic or other UV-sensitive materials.

Capacity of Storage tanks/reservoirs

The required storage capacity of a water reservoir depends on:

- The daily required volumes and quality of water measured in litres.
- The length of the dry seasons during which these volumes and quality of water are required.

Example on water demand for a homestead:

While the number of days in a dry season can be estimated fairly easy, such as 60 days without rain in a humid region, the volume of water required for each of the 60 days can be calculated using the following guidelines on daily requirements of water for a rural homestead

Eg a homestead with 6 persons, 4 local cows, 5 goats and sheep (shoats) and 20 hens who wants to irrigate ¼ acre with drip irrigation for 1 season of 60 days require the following volume of water for a 60 days dry season without any rains:

Daily water requirement	Water use	Amount Litres
60 litres per person per day	Clean water from roof for domestic use: 6 persons x 1200 L	7,200
30 litres per cow per day	Unclean water from a water hole in a riverbed: 4 cows x 1800 L	7,200
10 litres per goat per day	Unclean water from a water hole in a riverbed: 5 shoats x 600 L	3000
1 litres per hen per day	Unclean water from a ground tank or a pond: 20 hens x 60L	1,200
300 litres per ¼ acre per day	Unclean water from a ground tank or a pond: ¼ acre x 18000 / ¼	18,000
	Total storage requirement	36,000
	Add 20% loss due to evaporation and seepage	7200
	Total storage requirement for a 60 day long dry period	43,200

This example shows that a rural homestead require 3 types of water sources:

- A roof catchment tank with a storage capacity of at least $7200 + 20\% \text{ loss} = 8640$ Litres for fresh clean water for domestic use
- A well in a riverbed or a pond that can supply $7200 + 3,000 + 1,200 + 20\% \text{ loss} = 19,440$ Litres of unclean and, perhaps, saline water for the livestock
- A ground catchment tank or a pond that can supply $18000 + 20\% \text{ loss} = 21,600$ Litres of fresh but unclean water for drip irrigation

Rainwater collection and storage facilities require a variety of routine maintenance. Some of the routine maintenance activities that you will need to periodically complete are:

- Removing debris from the roof, leaf guard, gutter, gutter screen, and first-flush diverter.
- Inspecting and repairing vent screens.
- Siphoning sediment from the tank.
- Disinfecting the untreated-water storage tank

3. Water treatment

Contaminated water can be treated with physical or chemical methods.

- Physical methods contain sedimentation, filtration, boiling, and solar water disinfection.
- Chemical methods disinfect with chlorine, iodine, silver, or potassium-permanganate.

Most of the time, several of those methods are combined to get safe drinking water. The first step is normally to clean the water optically, i.e. sediment or filter the solid particles. Then, chemical or biological contamination can be removed by disinfection or chemical treatment.

Alternative purification methods include for example plants like a tree called Moringa which supports the coagulation and subsequent sedimentation of solid particles in turbid water. For many chemical or physical disinfection methods, turbid water is treated less effectively.

Although roof-based systems generally produce water with lower levels of chemical and biological contaminants, the water produced by both systems is subject to contamination and must be properly treated before it can be used.

The level of treatment you need to provide depends, to a great extent, on whether you will be using the water for potable purposes (such as drinking, food preparation, bathing, and dish- or hand-washing) or for non potable purposes (such as toilet flushing, clothes washing, and irrigation). Obviously, rainwater that is intended for potable use must receive a higher level of treatment than rainwater that is intended for irrigation purposes.

Contaminants found in rainwater

- Debris – these are any contaminant that you can see. Debris includes leaves and twigs, dust

and dirt, bird and animal droppings, insects, and other visible material. Although debris obviously reduces the aesthetic quality of the water, it can also pose unseen chemical and biological health threats. For example, leaves and dust can contain unseen chemical contaminants such as herbicides and pesticides. Similarly, bird and animal droppings can contain microscopic parasites, bacteria, and viruses.

- Chemical Contaminants -Although rainwater can be contaminated by absorbing airborne chemicals, most of the chemicals present in harvested rainwater are introduced during collection, treatment, and distribution. By properly designing and operating your rainwater harvesting system, you can minimize your exposure to a variety of chemical contaminants that include organic chemicals, such as volatile and synthetic organics, and inorganic chemicals, such as minerals and metals.
 1. Volatile organic chemicals (VOCs) can be introduced when rainwater comes into contact with materials containing refined organic products. These VOC sources include plastics, glues, and solvents, as well as gasoline, greases, and oils.
 2. Synthetic organic chemicals (SOCs) are chemicals that are typically found in pesticides, herbicides, and similar man-made products.
 3. Minerals are inorganic materials found naturally in the environment. Most minerals are inorganic salts (such as calcium carbonate, sodium bicarbonate, magnesium sulfate, and sodium chloride) that affect the flavor of the water but generally do not pose an actual health threat.
 4. Metals include lead, arsenic, copper, iron, and manganese. Some metals, such as lead and arsenic, can pose a long-term health threat if they are present in high enough concentrations..

- Microbiological Contaminants- Rainwater seldom contains any type of

microbiological contaminant until it is harvested and stored.

Microbiological contaminants that can cause a disease or infection are called pathogenic, while those that do not are called nonpathogenic.

Nonpathogenic organisms can be present in high numbers regardless of where your home is located.

Pathogenic microbes pose a greater health threat to rainwater users than most chemical contaminants, for a number of reasons, including:

- Pathogens can cause disease after a single exposure, while most chemical contaminants may require months or even years of exposure before causing a health effect.
- Pathogens do not affect the taste, smell, or appearance of the water. Many chemical contaminants, on the other hand, make the water taste, smell, or look different, especially if the chemicals are present at levels that would pose a short-term risk.
- Pathogen levels can rise very quickly, while chemical levels tend to remain fairly constant. Consequently, it is relatively easy (though somewhat costly) to periodically test for chemical contaminants, while it is both difficult and costly to continuously test for most pathogens.
- A disease caused by pathogens can usually be passed from person to person, while the health effects caused by chemicals affect only those that actually consume the contaminated water.
- Waterborne illnesses caused by pathogens can be a serious health risk for the elderly, infants, chemotherapy patients, and other individuals with a delicate or weakened immune system.

Pathogenic microbiological contaminants include certain types of protozoan parasites, bacteria, and viruses. The infectivity rates (the number of microbes required to cause a disease) and the virulence (the severity of the disease) vary, depending on the type of pathogen present and the immune system of the person that is exposed. Some pathogens can cause an illness if a person with a weakened immune system is exposed to just a few organisms.

As you design your rainwater treatment and treated-water storage facilities, you need to keep a few things in mind.

- The harvested water must be treated before it reaches the points in your home where it is consumed.
- The treatment system must be able to protect you and your family from a variety of chemical and microbiological contaminants.
- The treated-water storage tanks must prevent the treated water from being re-contaminated.
- The treatment and storage facilities must supply enough water to meet your family's needs at the instant that they need it.

The purpose of water treatment is to reduce or remove all contaminants that are present in the water and to improve water quality so that it is completely safe to drink. Water is unlikely to be completely free of contaminants at the original source. The types of water treatment processes depend on the characteristics of the raw water (untreated water direct from its source) and required water quality standards. Suspended solids, bacteria, algae, viruses, fungi, minerals such as iron and manganese, and fertilisers are among the substances that are removed during water treatment. (Suspended solids are tiny particles of solid material that are carried along or suspended in the water.)

Effective treatment should ensure the removal of all disease-causing agents and so reduce the possibility of the outbreak of waterborne disease.

Water treatment Technologies

a) Sedimentation

The first step of water treatment is often sedimentation, especially in the cases of turbid water. Generally, the methods used are very simple. The goal is to let the silt sink down and decant the clear water. Since this takes some time, the sedimentation process takes up to two days. Within this time, even pathogen bacteria can be reduced by 97%. Sedimentation can be done in

simple, covered containers. Also simple flow-through sedimentation tanks can be built.

Although the water is normally fairly clear after the sedimentation process, it is not treated enough for drinking. At least one further step, the filtration, is required.

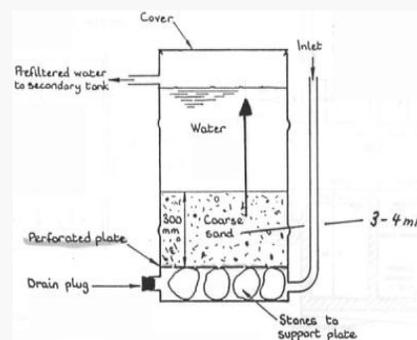
b) Filtration technologies

Filtration is the next step after sedimentation. It is an easy and cheap way to treat contaminated water. Depending on the type of filter, up to 100% of bacteria and most of the viruses as well as all bigger organisms (cyst, worm eggs, etc.) are being removed. There are multiple types of filters: sand filters, ceramic filters, and cloth filters.

You can use a variety of technologies to remove microbial pathogens from your harvested rainwater. Some of these filters can only remove relatively large particles, such as parasites, while other technologies can remove extremely minute particles, such as viruses.

- **Slow Sand Filtration-** Two types of sand filters can be compared: pressure filters and gravity filters. Pressure filters are often used in industrial water treatment. We will look at the gravity filters, which are much cheaper in set-up and maintenance, for small scale farmers.

The principle of a sand filter is the following: driven by gravity, water flows through a layer of previously washed sand and gets cleaned from solid particles, dissolved compounds as well as to a certain part microorganisms.



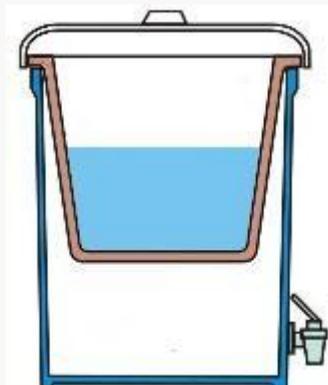
An example of a prefiltration tank, used for very silty water before cleaning it by a slow sand filter (Zumstein).

In slow sand filtration, a biological layer is formed on top of the sand, which is additionally active in deactivation and removal of pathogens from the water. The advantage of slow sand filters is that they can be built locally with local materials.

When properly maintained, they remove 90-99% of bacteria and also other pathogens. But they require the proper maintenance such as regular cleaning by scratching away the biological layer on top of the sand. During the first 1-2 weeks of use, the water is not cleaned, because the biological layer has to grow first. Also after cleaning, the filter needs some time to recover.

If the filter has to be cleaned very often, the water is too silty and should be allowed to stand in a large tank or pre-filtered beforehand. For pre-filtration, an upward flow filter is useful. In an upward flow filter, the bed of coarse (3 to 4mm) sand is supported on a plate pierced all over with 2mm holes 50mm apart. The advantages of the upward flow filter are that it is easy to clean the sand bed once a day by shutting of the flow and pulling the drain plug.

- **Ceramic filters**-Ceramic filters have a pore diameter of about 200nm, which means that it can filter bacteria (usually bigger than 300nm) and reduce but not totally filter viruses (which can be as small as 20nm). One simple form of ceramic filters is clay pots. The ceramic filters often have a coating of colloidal silver, which acts as bactericide and enhances in that way the purification effect. Furthermore, the silver hinders bacteria to grow on the ceramic filter surface.



Other example of a ceramic filter

Also ceramic filters remove 90-99% of bacteria as well as other pathogens. But compared with slow sand filters, their through flow is much smaller, so they are suitable only for household use. Ceramic filters need regular cleaning and proper handling, so they don't break.

- **Cloth filters**-Cloth filters, mostly made of cotton also filter particles with the size of their pores. Since microorganisms are associated with plankton or other bigger particles, they can also be removed by filters with bigger pore sizes than the size organisms themselves. Cloth filters showed to be effective against cholera or the Guinea worm.

Cloth filters should only be used as a last means if no other way of water purification is available since its effectiveness is lowest compared with the other described filter methods.

c) Boiling

Boiling is the simplest method to remove all pathogens from water. Water needs to be boiled shortly at least 70°C. If the water is heavily contaminated, a boiling duration of 3 minutes is recommended. The water should not be poured in another vessel since it could be re-contaminated.

The disadvantage of boiling is the bland taste of the water after cooking and the large amount of energy needed. For one litre of water one kilogram of wood is needed for boiling. In areas with scarce wood availability, it is often hard for the women to collect enough fire wood even for cooking. In forest areas, water treatment by cooking increases the pressure on the forest, which can lead to deforestation and subsequent problems like erosion, water scarceness, and loss of biodiversity.

- d) **Disinfection Technologies** Although there are numerous disinfection technologies, some of them are more appropriate for home use than others. We recommend that you consider using a combination of ultraviolet light and chlorine for the following reasons.

- **Solar water disinfection-** Ultraviolet light (UV) is extremely effective against Cryptosporidium, but high doses are required to inactivate some viral pathogens. In addition, UV systems do not maintain a disinfectant residual in your plumbing system.

Microorganisms which occur in some water resources used as drinking water can cause water borne diseases such as diarrhoea.

SODIS is seen by the World Health Organization (WHO) as one of the technically simplest and most practical and economical ways to improve the quality of such drinking water. Water that is contaminated with microorganisms is filled into clean, transparent plastic bottles and exposed to full sunlight for six hours. The solar radiation and temperature destroy the micro-organisms in the water. This method is ideal to produce small quantities of safe drinking water for the household level.

The WHO recognizes that heating water, other liquids and other foods using solar radiation is a more accessible, economical and technologically feasible option than heating with fuel.

Requirements for SODIS

- **Containers** -Plastic bottles made from PET are good containers for SODIS. PET soft drink bottles are often easily available. The containers used for SODIS should not exceed a water depth of 10cm, i.e. PET bottles of 1-2 litre volume.-To distinguish a PET- from a PVC-bottle, try to inflame it. PVC is difficult to flame. The material does not burn outside the flame. The smell of the smoke is pungent. PET burns easily when held into a flame. The fire goes out slowly or not at all outside the flame. The smell of the smoke is sweet. You should not use PVC bottles for SODIS.
- **Water turbidity and quality** -Solar Water Disinfection does not change the chemical water quality. Do not use chemically polluted water. SODIS requires relatively clear water. To test the water turbidity, there is a very simple test: Fill the SODIS bottle with the water and place the bottle on top of a paper

with the SODIS-Logo (the letters should have a size of about 1.5cm). Open the lid of the bottle and watch through the bottle to the bottom of the bottle. If you still can read the letters of the SODIS-Logo on the paper, you can use the water for SODIS. If you cannot read the letters, the water is too turbid for SODIS and needs to be filtered or the solids have to be decanted first. Let the full bottle stand until the suspended particles have sunken to the ground. Filter the water through a clean cotton cloth or filter and fill it into a new bottle without the sunken particles.

Application of SODIS

- **Step 1: Aerating the water** – Wash the bottle well the first time you use it. Fill the bottle to 3/4 and close it. Shake it a few times. Then fill it completely with water. This procedure is particularly important if you treat standing water (as it is the case for stored rainwater). Oxygen in combination with sunlight helps destroying the micro-organisms in the water. After shaking, the bottle should be filled completely.
- **Step 2: Exposure to the sun** – The bottle needs to be exposed to the sun for 6 hours if the sky is bright or up to half cloudy. If the sky is completely cloudy, then the bottle needs to be exposed to the sun for 2 consecutive days. After this time, the water is ready for consumption

During days of continuous rainfall, SODIS does not perform satisfactorily. Rainwater harvesting is recommended during these days.

Place the bottles on a surface: It needs to be fully exposed to the sun, and never shaded during exposure. Protect the bottles from wind cooling - do not place on open wood racks. Place the bottles on surfaces reflecting the sunlight such as corrugated iron sheets, which can enhance SODIS efficiency. Never place the SODIS bottles on inflammable materials, such as cloth or straw. Since the bottles can act as a magnifying lens, they can set fire to inflammable materials.

Increasing the efficiency of Solar Water Disinfection

Place the plastic bottles on a corrugated iron sheet, (this will increase the water temperature by about 5°C.) Use raw water with low turbidity, expose the bottle for two consecutive days on cloudy days, and replace scratched and dull bottles after about one year of regular daily SODIS application.

Common mistakes made in SODIS

1. The containers chosen are too big -For the best results, plastic bottles of 1-2 litres volumes are used (better surface/volume ratio).
2. Bottles are placed upright-Laying the bottles horizontally increase the area for sunlight exposure and reduce water depth. Like this, micro-organisms are more easily destroyed.
3. After SODIS treatment, the clean water is filled into contaminated containers and the water is re-contaminated. -Consume the treated water directly from the bottle using a clean glass or a cup.
4. Green or brown plastic bottles are used for SODIS -Green or brown bottles do not sufficiently transmit the sunlight. Therefore, use clear transparent bottles only.

Effect of aerating the water

With the aeration, oxygen is dissolved in the water. SODIS is more efficient in water containing high levels of oxygen: Sunlight produces highly reactive forms of oxygen (oxygen free radicals and hydrogen peroxides) in the water. These reactive molecules react with cell structures and kill the pathogens.

Recent research however revealed that the bottles should be shaken only at the beginning of the SODIS process. Once the bottles are exposed to the sun, they should not be moved anymore, as continuous shaking of the bottles during the solar exposure will reduce the efficiency of the process.

The taste of solar disinfected water

When water is boiled, the level of the oxygen dissolved in the water decreases. This changes the

taste of boiled water, making it tasteless, fresh and softer.

SODIS on the other side improves the quality of drinking water without changing its taste. The bottles are closed during the exposition to the sun. Therefore, the level of oxygen dissolved in the water remains the same. The taste of the water keeps fresh.

Limitations in SODIS application

- Availability of suitable water containers and other needed materials
- Lack of sunlight for disinfection
- Difficulties in treating highly turbid water and the availability of simple methods for reducing the turbidity of water before solar treatment (turbidity less than 30 NTU needed)
- Lack of a residual disinfectant to protect water during handling and storage. However, stored in the bottle, the treated water is protected from recontamination. No re-growth has been observed so far, even if the treated water was stored for one week.
- User objections to the technology due to the length of time to treat the water (several hours or longer)
- Lack of effectiveness against chemical water pollutants
- Not useful to treat large volumes of water
- Weaning food for children less than 18 months should be prepared with boiled water.

Boiled water instead of SODIS water should be used by persons with a considerably increased risk of infectious diarrhoea diseases including:

- a) severely ill children and adults
- b) severely malnourished children and adults
- c) patients with decreased immunodeficiency (AIDS)
- d) patients with gastro-intestinal abnormalities or chronic gastrointestinal illnesses

• **Chlorination**- Free chlorine is very effective against viruses but is virtually ineffective against *Cryptosporidium*. In addition, it is easy to

maintain and measure free chlorine residual in your plumbing system.

Chlorination is still a worldwide used method for the disinfection of water. When used with water filtration methods, chlorine is effective against virtually all microorganisms. Chlorine is easy to apply and small amounts of the chemical remain in the water as it travels in the distribution system or is stored in a tank or cistern. This level of effectiveness ensures that microorganisms cannot re-contaminate the water after treatment.

Chlorination is useful for the treatment of a central water supply in a village but not for individual household use, since its application has to be done in a professional way. The application of chlorine can produce certain by-products that can lead to health problems.

Chlorine can also be used as an emergency measure for the disinfection of a water storage that has been accidentally contaminated, e.g. after a storm or by a dead animal.

4. Waste water management

Water is one of the most valuable resources on Earth. Water and sanitation have a great effect on human health, food security and quality of life. Demands on water resources for household, commercial, industrial, and agricultural purposes are increasing greatly. Yet water is becoming scarcer globally, with many indication that it will become even more scarce in the future. More than one-third of the world's population; roughly 2.4 billion people live in water-stressed countries and by 2025 the number is expected to rise to two-thirds.

Growing demand for water due to the growing world population is creating significant challenges to both developed and developing countries.

On-site wastewater reuse can reduce water use in both urban and rural households. At present, most homes use potable (drinkable) water for practically everything in the house and garden.

Opportunities to reuse wastewater and regulation of its treatment vary according to where you live.

Urban households typically have a connection to a centralised, or reticulated, sewage system, whereas rural households manage their wastewater on site. Check with your local council or state health authority for advice on the regulations in your area.

Two types of wastewater are created in a home: grey-water and black-water.

Grey-water is wastewater from non-toilet plumbing fixtures such as showers, basins and taps.

Black-water is water that has been mixed with waste from the toilet. Because of the potential for contamination by pathogens and grease, water from kitchens and dishwashers should be excluded from grey-water and considered as black-water.

Each wastewater type must be treated differently and can be used in various ways.

- Grey-water is ideal for garden watering, with the appropriate precautions, such as using low or no sodium and phosphorus products and applying the water below the surface. Appropriately treated grey-water can also be reused indoors for toilet flushing and clothes washing, both significant water consumers.
- Black-water requires biological or chemical treatment and disinfection before reuse. For single dwellings, treated and disinfected black-water can be used only outdoors, and often only for subsurface irrigation. Check with your local council or state health department on local requirements. Many different indoor locations generate wastewater.

For grey-water:

- Minimise the use of cleaning chemicals. Use natural cleaning products where possible.

- Use low or no sodium laundry detergents, soaps and shampoos.
- Use a lint filter. Clean and replace as necessary to ensure water can flow through it easily.
- Do not dispose of household chemicals down the sink. Contact your local council or water authority for information on chemical collection services.

For black-water:

- Minimise the use of cleaning chemicals. Use natural cleaning products where possible.
- Do not dispose of household chemicals down the toilet.
- Use a sink strainer in the kitchen to help prevent food scraps and other solid material from entering your wastewater.

Wastewater reuse in rural areas

Rural households typically have greater scope for reusing wastewater because:

- without a centralised treatment service, investment in an on-site wastewater treatment system is a necessity
- installing a reuse system in a new house, or adapting an existing treatment system to allow reuse, may not incur significant additional expenditure
- water supply may be restricted, placing a premium on using water resources in the most efficient manner (see Reducing water demand; Rainwater)
- large blocks of land in rural areas allow more scope for on-site disposal of wastewater.

Reusing wastewater outdoors

Reusing wastewater outdoors can reduce a household's potable water use by 30–50%. However, a number of precautions need to be taken to ensure it is safe and environmentally sound.

Avoid watering vegetables with reuse water if they are to be eaten raw. There is a chance that some pathogenic organisms may still be present even after treatment. To maintain the health of your garden, the level of reuse of wastewater needs to be balanced with the amount of water,

solids and nutrients that the plants and soil in the garden can absorb.

If excess wastewater is applied:

- excess nutrients may run off or leach through the soil to enter waterways, contributing to algal blooms and other water quality problems
- soils and plants may become waterlogged and inhibit plant growth
- soils can become physically clogged with organic and suspended material or damaged by salts in the wastewater
- salinity may increase in problem areas when grey-water contributes to rising water tables.

Avoid these problems by:

- planning your garden carefully (see Outdoor water use; Landscaping and garden design)
- using phosphate-free and salt-free liquid or environmentally friendly detergents
- pre-filtering to remove solids.

Adjust the amount of wastewater to conditions in the garden. Do not irrigate if the soil is already saturated

Grey-water treatment for outdoor use

Grey-water can be reused in gardens with little or no treatment.

Wet weather storage

Wastewater reused in the garden needs to be disposed of or stored when it is not required during periods of high rainfall. If storage is not an option, excess wastewater can be directed to a sewer in an urban area. In rural areas with enough space, subsurface disposal to a trench in the garden is recommended.

Storage maximizes the usefulness of wastewater but it needs to be treated and disinfected before storage.

Storage requirements depend on:

- climate
- household demand for reuse water

- presence/size of disposal area
- maximum daily wastewater output.

Reusing grey-water indoors

- In homes with access to a reliable rainwater supply, it is generally more economical just to use grey-water outdoors and rainwater indoors. However, if you are unable to collect enough rainwater, treated grey-water can reliably reduce indoor water use.
- Appropriately treated grey-water can be reused for toilet flushing and clothes washing, which are two of the biggest users of water in an average household

NOTE: Wastewater from the kitchen sink and dishwasher can be classed as grey-water but requires more complex treatment before reuse.

Grey-water can be directly diverted from the shower or bathroom sink for toilet flushing as long as it is used immediately and not stored for more than 24 hours before reuse or disposal to sewer. It requires coarse filtration.

Precautions

Grey-water must be treated and disinfected before storage and general reuse because it:

- can contain significant numbers of pathogens that spread disease
- begins to turn septic and smell if stored for longer than 24 hours untreated.

Dissolved organic material in grey-water reused for washing clothes may dis-colour clothing. An activated carbon filter can overcome this problem.

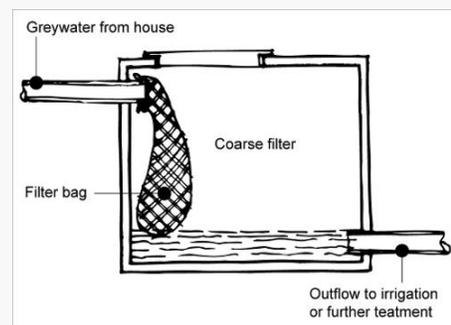
Treatment systems for indoor grey-water reuse

The treatment processes may employ biological, chemical or mechanical means. The qualities of

treated water they produce can vary considerably, as can their initial cost and energy consumption.

Grey-water treatment generally consists of several steps:

- Coarse filtration to remove large particles, including hair, and prevent clogging. It can be as simple as a waterproof box and a filter bag or stocking attached with rubber bands. Check the stocking or bag frequently and replace it when full.
- Fine filtration and biological treatment, using a sand filter and reed bed combination. Microbes in the sand break down organic matter in the water and the reeds take up nutrients. The basic structure is a waterproof box filled with coarse sand laid over a gravel bed. It is designed so that grey-water percolates either vertically or horizontally through the media.
- Any grey-water reused indoors must be disinfected. All disinfection systems require frequent maintenance. Chlorine, although the most common disinfectant, has been found to have adverse environmental impacts. Alternatives such as solar disinfection (UV) should be used where possible



A sample systems for treating grey-water

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CHAPTER 8: SEED MANAGEMENT

1. Introduction to seed management.

A seed is a mature ovule consisting of an embryonic plant together with a store of food, all surrounded by a protective coat. A seed may be any plant part used for the purpose of further propagation or multiplication. It is also termed as propagule

A plant is a living material and its ultimate goal is the multiplication of the parent material. It is done through one or another part of the body.

There are several parts of the plant which act as the “Seed”.

- Matured and fertilized ovule turns into seed example maize and rice.
- A part of the stem can grow into a plant, example cassava and sugarcane.
- An underground stem, that grows horizontally and sends up leaves and flowers, can grow into a plant, example ginger and certain flowers.
- A tuber or underground A tuber stem, acts as seed, example potato and yam, etc.
- Some plants grow small offshoots from the lower part of the plant. Which grow into new plant, example pineapples, plantains and bananas.

Importance of Seeds

- Seed is the starting point in crop production.
- Seed is the most important inputs.
- Seed carry a specific genetic potential
- Farmer can increase yield up to limit of seed potential.
- Agri - inputs and proper farm practices, help to exploit the genetic potential of the seed.
- Seed is living matter and can deteriorate if not handled and stored properly.

Difference between certified seed and grain seed.

Certified seed	Grain (local seed)
It results from a well planned production programme	It is part of commercial produce, saved for sowing/planting purposes
It is a result of sound scientific knowledge, organized effort, investment on processing, storage and marketing facilities	No such knowledge or effort is required
The pedigree of the seed is ensured. it can be related to the initial breeders seed	Its varietal purity is unknown
The seed is tested for planting quality, eg germination, analytical purity, seed health and moisture content	Routine seed testing is not done
The seed is scientifically processed, treated and packed and labeled with proper lot identity	The grain used as seed may be manually cleaned. In some cases prior to planting it may be treated. Not labeled
During production, effort is made to rogue out other off types, weeds, diseased plants, to endure seed purity and health	No such effort is made. Hence the purity and health status may be inferior.

Seed diversity has always been a cornerstone of people’s livelihoods in rural areas of Kenya. There is evidence that crop diversity has changed over time mainly due to governmental projects and the introduction of high-yielding varieties and cash crops.

Crop diversity is therefore an essential part of the FAO definition of seed security, which includes “timely availability of seed of improved variety and ecotype of staple crop kinds to farmers, especially after a disaster, and its efficient distribution at the right place and at an affordable price” (FAO 1997).

Some main observations to seed diversity include:

- As cropping systems become more commercialized, there is a reduction in crop and varietal biodiversity.
- Cash crops provide income that can be used to supplement family food needs during staple crop shortages.
- There is a clear tendency to manage traditional crops and cash crops at the same time to broaden livelihood options. Many farmers maintain traditional crops on a reduced scale.
- Women take a leading role in conserving and managing traditional crops and varieties.

Before planning any seed management intervention, it is important to understand the differences in seed demand and the flow of genetic materials for different socio-economic groups (better-off, medium and poor households) and between men and women

Seed management:

The introduction of new crops and varieties through the formal system offers the potential for farmers to experiment with new seed material and to broaden their choice of seed supply. However, it may also undermine existing local structures as the formal system often distributes seed as part of subsidized programmes, which come with other external inputs and may bias farmers' selection of seed

The collection of wild plants and minor crop species is another strategy to achieve food security, which has not been affected or replaced by the introduction of new crops and varieties.

Wild plants such as wild fruits, greens and vegetables are consumed throughout the year as farmers are knowledgeable about how to process and conserve them. Women favour minor crops such as pumpkin, cucumber, sponge gourds and watermelon as they are easily available, not labour-intensive and provide healthy food during staple crop shortages, usually between February and June (FAO 2007)

Managing seed diversity is key to increasing biological and cultural diversity. Plant genetic diversity is crucial to breeding food crops and is thus one of the central preconditions for food security. It is also vital to modern plant breeding, as it provides the genetic traits required to address crop pests, diseases and changing climate conditions.

Gender, social and economic factors to seed security.

There are important socio-economic and gender differences when it comes to seed diversity, seed security and food security which need to be understood to effectively target any seed intervention.

- Better-off households manage fewer diverse crop systems since they are more market focused and grow a larger share of improved varieties of cash crops. At the same time, these households grow local crops for food consumption.
- Improved and hybrid varieties are commonly used by better-off farmers, while these varieties are less used in poorer households. However, even resource-poor households try to obtain improved crop varieties and may have access to them through local seed distribution channels.
- Wealthier households were more likely to conserve and control their own seed, while poorer households more often supplemented their limited seed stock with whatever was available to them, which was often seed of poor quality or varieties unsuitable for the local environment. (FAO and ICRISAT 2004).
- The poorest households are the most seed insecure, since they generally fail to produce enough crops to keep seed throughout the year. They access seed largely through the exchange of labour for seed and occasionally they acquire small quantities as supplies at no cost. (Lazaro and Bisanda 2004).

Types of Seed

Seed is produced mostly by transfer of pollen (male parts) to female parts of the flower and is called-Pollination. It is carried out by wind, insect, birds, or other natural agents.

- **Open-pollinated Varieties (OPV) seed-** An open – pollinated Variety seed is one in which pollination is carried out from either the same (parent) plant.
- **Self-pollinated Crops seed-** Those plants that pollinate themselves by accepting pollen from within their own flower before it open. The seed saved from both an open and self pollinated variety can be used for planting in a few subsequent years on.
- **Hybrid seeds-** Hybrid seeds are produced through a controlled cross pollination of one specific variety of a class of plant with the pollen of another genetically different variety of that class.
- **Genetically-Modified Organisms (GM or GMO) seeds-** Genetic modification is the transfer of specific genes into the plant in a laboratory. The genes introduced in the plants include the capability and characteristics of the species of plants, bacteria, or animals that have been transferred from external sources

Facts about Farmers saved seeds

Most farmers have a tendency to save their own seed for economic reasons. This should only be self or open pollinated varieties. However such Seeds are not well cleaned and treated, which lead to problems with weeds, plant diseases, and consequently low yields.

In addition, farmers continue to use their own saved seed for many years; the seeds get mixed from crossing with surrounding inferior varieties or become susceptible to diseases.

Seed renewal is therefore critical every 3-4 years, if the farmer is to continue profitable farming.

Seed selection, breeding and certification

Seed selection

Studies reveal a clear difference between men and women's responsibilities with respect to crops and seeds. Women are involved in producing subsistence food crops such as beans, peas, potatoes, cassava, finger millet, and vegetables, while men are more concerned with producing crops for cash. In addition,

Seed selection is mainly done by women, while men are responsible for constructing adequate seed storage structures

Women play a central role in managing agrobiodiversity and the knowledge of seed selection, production and supply. As women are mainly responsible for seed selection and management of traditional food crops, they also hold a higher level of knowledge about these crops than men (FAO and ICRISAT 2004). For example:

- Nutrition and health needs are most often women's responsibility.
- Women often use a broader set of selection criteria than men, since they use plants in more diverse ways (Howard 2003). Whereas men generally focus on criteria related to agronomic characteristics and market value, women apply additional criteria related to food consumption, such as palatability, taste and cooking qualities.

Furthermore, men and women share criteria related to the quality of seed, such as seed size and freedom from pests. (FAO 2007)

On the other hand, the formal system of supply of hybrid seed has failed to meet their demand for seed. The main reasons stated for the ineffectiveness of the supply system include:

- Prices of improved varieties are often not affordable.
- Seed is offered in large quantities.
- Quality of seed is not always good.
- Seed may reach the villages at times unsuitable for sowing.
- Focus is on improved crop varieties of selected staple and cash crops.

In addition, farmers have expressed an interest in obtaining improved varieties and new crops and would like improved access to the formal system. Currently, this interest is often satisfied through other channels, such as private seed traders, stockists in town and non-governmental organizations (NGOs). (FAO 2007).

Stages in Development of Improved Seed

- Breeder Seed - Breeder seed is the initial seed produced by the breeders under controlled conditions
- Pre-Basic or Foundation Seed -Progeny of the breeder seed produced under the supervision of the breeder
- Basic or Registered Seed-Registered seed produced under the supervision of a breeder/ designated agency under the control of a seed quality control agency.
- Certified Seed-Produced by contract growers, from the registered seed and Inspected by seed quality control agency

2. Seed quality and viability

Successful crop production heavily relies on the supply of quality seed. It is the degree of excellence in regard to the characteristics of a good quality and depends on a number of factors starting from the time the plant is growing in the field, to processing to marketing. Therefore seed quality is affected by a number of factors such as:

- environmental factors affecting plant growth
- Processing methods
- Storage methods

Components of seed quality include:

- Genetic purity
- Analytical purity
- Seed viability and germination capacity
- Seed vigour
- Seed size
- Seed health
- Seed moisture content
- Seed longevity
- Seed deterioration

Genetic purity-It is the genetic characteristic of a particular cultivar variety. It is also called cultivar purity(trueness to the parent type)- it is a factor of the following characteristics

- Low or high yielding
- Early or late flowering and maturity
- Determinate or in-determinate growth habit
- Short or long plant size
- high or low nutrient requirement
- Disease or pest resistance
- Stress tolerance
- Nutritional value

Analytical purity-This refers to the proportion of pure seed in a seed lot. Eg 10%, 20% -given in percentage. The higher the percentage indicated the better the seed quality. This is calculated by analysis of a small sample in a seed lot to determine the % of other seeds of different cultivar, weeds (impurities) and expressed as a % of the total – (expressed in % by weight)

$$\frac{\text{.....gms(impurities)}}{\text{.....gms(total weight of sample)}}$$

For most seeds, the standard analytical purity value should be at least 98%

Weed seeds should be avoided 100% at all cost. Recommended weed seed rate should be 0%

Seed viability and germination capacity-Seed viability refers to the capacity of a seed to germinate and produce a normal seedling. The germination capacity is normally expressed as a % of seeds that produce normal seedlings.

For a seed lot to be declared of good quality seed, the germination % should be as high as possible at least 90%

Analytical quality and germination capacity can be combined to give a parameter of pure life seed-defined by the proportion by weight of a given seed-lot that is capable of germinating to produce a healthy and normal seedling.

There are several shortcomings to lab germination tests – leading to over-estimation of the actual field emergency (a high germination % does not necessarily indicate high emergency% of a seed lot in the field. It fails to provide accurate information of the seed-lot performance in the field

Some of the reasons include;

- In germination test, the focus is only on the structures coming out(radical which does not show its vigorous indication in the field
- It does not show the rate at which the plant is growing
- It only gives an indication of viability in filed (whether it will germinate or not)
- Field conditions are not reflected in the lab tests.

Seed Vigour-Seed vigour is the ability of seeds to germinate and establish healthy seedlings under field conditions. This was developed because of the inefficiency in germination tests This is measured by the mean germination time in the field. The less the number of days it takes the higher the vigour

Seed size-Seed size is determined by the position of the seed o the plant and in the inflorescence. i.e seed at the top of the plant tend to be smaller that seeds at the bottom.

Seeds that are closer to the leaves and exposed to sunlight tend to be larger than those in the shadow areas. Seeds that develop late are smaller, due to in adequate photosynthesis. The higher the seed size, the higher the vigour.

Seed size is expressed in weight (of 1000 seeds for smaller seeds) and (100 seeds for large seeds crops). Large seed produce larger, strong seedlings which have better emergency than the smaller ones. (Have adequate stored nutrient in the seed-thus can supply embryo for fast growth.

Good seed lot must have uniform seed to achieve

- Uniform emergency
- Uniform establishment
- Uniform crop growth

Seed Health-This is the freedom of a seed lot from disease pathogens. Some of the diseases that are seed borne include: alternaria brassicola, Ascochyta leaf spot, bean anthracnose, downey mildew, bacterial wilt, fusarium wilt, smuts(ushlago maydis), mosaic viruses

Seed Moisture-Seed moisture affects seed longevity, processing(threshing) and attack of pathogens. Seeds with moisture content of 14% or less can be stored for few weeks, 10% for medium term while 5-10% for long term

Seed Longevity-Refers to how long the seed can remain viable after dormancy is released Species with 1-year longevity do not have good longevity. Longevity of many years is good

Longevity	Crop type
1 years	Onion, parsley, lettuce,
2 years	Maize, leek, okra, pepper,
3 years	Asparagus, beans, Brussels sprouts, Carrot, cabbage, celery, spinach, pea, kohlrabi
4 years	Beets Cauliflower, eggplant, squash, Tomato, turnip, pumpkin, watermelon, kale, swiss- chard
5 years	Collards, cucumber radish, etc

3. Seed dormancy

Seed dormancy

This is the failure of a fully develop and mature viable seed to germinate under favourable conditions of moisture and temperature. This condition is also called resting stage, period or dormancy. This seed is called a dormant seed.

Importance of seed dormancy

- Allows seed to survive in adverse conditions
- Seeds can be stored till the next season and be transported to another place without losing viability
- Allow seed to be used in research – as gene pool

- Some seeds can be kept in cold conditions to get better price when there is off season
- Due to dormancy, spp are saved from wipe out in case of calamity
- Seed survival
- Creation of a seed bank
- Seed disposal- seed coat scarified by passing through a birds or animal tract

Disadvantages of seed dormancy

- Some seeds will not be sown immediately after harvest
- Noxious weed seed remains dormant for many years in the soil and thus eradication becomes impossible
- Poor germination and growth

Type of seed dormancy

1) Primary dormancy-

It occurs in freshly harvested seeds and can only be induced through the maturation of the seed.

Causes of primary dormancy

- Seed coat- not allowing absorption of water
- Chemical inhibitors on the seed coat
- Morphology or shape of seed-being not conducive for seed germination and absorption of water
- Physiological requirements or a combinations of the above

Types of primary dormancy

A. **Exogenous dormancy**-normally imposed by embryo factors outside the embryo- on the seed coat

- i. Physical attributes of the seed coat being impermeable to water
- ii. Mechanical exogenous dormancy- seed coat being too hard to allow embryo inside to expand and break through during germination.
- iii. Chemical exogenous dormancy –the seed coat having chemical inhibitors that inhabit germination.

B. **Endogenous dormancy**- normally caused by factors within the embryo

- i. Morphological dormancy- the embryo is immature morphologically in terms of size- thus needs further growth after the seed or fruit is separated from the plant. Germination is prevented until the embryo reaches the specific critical size for that spp
- ii. Physiological dormancy- requires some type of physiological condition to germinate- eg to be dried/ dehydration, exposure to light, exposure to low temperature.

Eg – Carrot, tobacco require absolute requirement of light, while for datura, exposure to light is inhibitory for germination.

C. **Combinational dormancy**- occurs when there seeds have impermeable seed coat combined with physiological and chemical causes

2) **Secondary dormancy**- refers to the imposition of a new dormancy in seed after the primary dormancy has been overcome. The main cause of secondary dormancy occurs during the activation process/ phase of germination. Factors include: temperature extremes, prolonged darkness, prolonged light, water stress and oxygen extremes.

Methods of breaking seed dormancy

a. Mechanical treatment of seeds

The dormancy can be removed by mechanically weakening the seed coat – through a process called scarification

- Filing(using sand)
 - Chipping(using knife)
 - Piercing(using needle)
 - Chilling(using low temperature)
 - Pre-drying(using high temperature)
 - Pre-washing/leaching (using water)
 - Pre-soaking- using warm water
- b. Chemical treatment seeds are dipped in an organic solvent eg alcohol, acetone) to cause degrading of the seed coat and dissolving of waxy coating

- c. Use of growth regulators- germination can be influenced by using growth hormones (GA3, IBA, NAA, 2,4-D)

4. Factors affecting seed growth and development.

A. Agro-ecological factors

i. Temperature

Most of the crops require moderate temperatures for flowering and pollination such that good seed are formed. Too high temperatures cause desiccation of pollen resulting in poor seed set

ii. Rainfall

Excessive rainfall leads to higher incidence of pests and diseases and makes seed useless. It may result in delayed maturity and pre-germination of seeds in many standing crops.

Heavy rainfall has the following effects

- Poor seed set
- Increased Flower drop
- Reduced seed size
- Reduced seed yield

iii. Day length(photoperiod)

Ample day length is required for better seed development and maturation and the ripening of the seed on the parent plant.

iv. Winds

Strong winds at or near harvest time causes heavy seed loses

B. Nutrition

This includes the structural and textural status of the soil, its fertility level, pH, microbial environment. In the nutrition of seed crops- nitrogen, phosphorus, potassium and several other elements play an important role for proper development of seed. However, excess nitrogen prolongs the growing period and delays the seed maturity.

Severe nitrogen deficiency in carrot, lettuce and pepper result in poor seed development

C. Soil moisture

For good quality seed, a relatively dry climate during ripening phase is preferred. Extreme, water

deficit stimulates desiccation, and affects the quality of seed.

5. Seed harvesting, threshing, cleaning, drying and storage.

Proper post-harvest processing is critical to maximize yield, longevity, vigor, and overall quality of the seed crop. At maturity, seed must be harvested, threshed, cleaned, and fully dried before storage. Each of these steps requires proper timing, skills, and in some cases, equipment. Investing in the long growing season of a seed crop, only to lose it with improper harvest and post-harvest handling, is an incredibly frustrating experience

Seed processing

• Threshing-

Seeds and plant materials should be dry before threshing. This can be checked by squeezing a handful of seed and plant material. Dry seed and plant material will not have any give while moist materials will give in your hand. If the seeds can be squeezed, or "give" in your hand, or the plant material feels moist, they are not yet dry. For many crops, seeds can be stripped from the plant by hand before threshing in order to minimize the amount of material that must be dried and broken up.

Threshing is the process of removing seeds from the plant and breaking up remaining plant materials (e.g., stems and leaves), into what is called chaff. The dry seed heads attached to the plants are rubbed or crushed to release the seed and break down the plant material. This step facilitates the subsequent separation of the seeds from the plant materials in the seed cleaning process. Threshing may be done by hand or machine, depending on the scale and type of seed to be processed.

- **Drying** Seed received from farmer's field is dried to required moisture content.

- **Cleaning**-All foreign material should be removed by sieving, winnowing and other methods.
- **Seed Treatment**- seed must be treated to protect it during storage and also in the initial stages after planting. Seed is treated with fungicides and insecticides for protection.
- **Bagging or Packaging**-The seed should be packaged in bags and Labeled, providing necessary information.

6. Seed packaging, bulking and storage

Seed is living matter and if not handled and Stored properly seeds “die”

The main reasons for seed deterioration are as follows:

- High temperature in the seed store
- High humidity in the storage area.
- Handling & storage of seed
- High moisture content of the seed itself.
- Storage in improper packaging that cannot
- Prevent moisture from entering the package.
- Use of incorrect chemicals for seed treatment.
- Storage of un-cleaned and untreated seed.
- Presence of pests and diseases.
- Extreme temperature (too hot or too cold) can lead to serious seed damage.
- High humidity in the store can lead to serious seed damage through mold formation.
- High humidity also encouraged growth of insects and pests in the store.

Measures to avoid seed deterioration during packaging and storage.

- Seed bags should not be thrown carelessly.
- Seed bags should be stored in dry, well ventilated stores.
- Always use slatted wooden pallets or PVC sheets spread on floor.
- Recommended moisture contents for seed storage is 12%.

- Avoid storage of seeds together with chemicals, especially those that emit vapors.
- Avoid the sale of seed from open bags or containers.

Storage

Indigenous knowledge is eco friendly and safe both to man and his environment. It is estimated to 60-70% of food grain produced in the Kenya is stored at home level in indigenous structures ranging from Granaries, gunny bags and modern bins. Proper storage of seed is necessary to protect from spoilage, increasing storage quality, germination % and viability% of the seeds. Traditional technical skills teach us how to best utilization of natural sources for protects storage life of seed.

The purpose of seed storage is to maintain the seed in good physical and physiological condition from the time they are harvested until the time they are planted

General principles in seed storage

- Seed storage conditions should be dry and cool
- Effective storage pest control
- Proper sanitation in seed stores
- Before seed storage, they should be dried to safe moisture limits, appropriate for storage systems
- Store high quality seed and well cleaned, treated as well as of high germination vigour and good pre-storage period.
- Seed longevity is improved by storing seeds in low temperature and low moisture content

Relative storability index

Period	crop
1-2 years	Green bean, lettuce, onion, pepper
3-5 years	Broccoli, cabbage, cucumber, peas
>5years	Beet, tomato

Seed Storage methods

a. Sealed containers

- Aluminum or plastic cans
- Aluminum pouches
- Plastic bottles
- Waxed boxes
- Laminated paper bags

b. Open storage

This does not have temperature or relative humidity control

Needs basic protection from water, contaminating agents and rodents

c. Conditioned storage

This is more commercial, with conditioned temperature and humidity control. Used for high value seeds

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CHAPTER 9: NURSERY ESTABLISHMENT AND MANAGEMENT

1. Introduction to nursery establishment

A Nursery is a protected environment /seedbed for the production of planting materials before establishing them in the main field.

A plant nursery is a place used for germinating seeds or growing plants before transplanting to permanent sites (field, farm). Establishment in permanent sites depends on how plants were propagated and grown in the nursery.

Nurseries differ in size and diversity: some nurseries diversify, while others specialize in growing crops specific or suitable for certain geographic region.

Nursery Management is bringing together men (people), money and materials in a framework time, for an economic purpose. Quality nursery stock requires quality nursery management.

The goal of a good nursery manager is the timely and cost efficient production of healthy, uniform plants with a strong fibrous roots system will enable the plant to get established quickly in the field.

Nurseries are established where:

- Seeds are too small to be sown directly in the main field
- Seedlings are delicate when young hence require extra care
- Management is eased by watering, weeding etc

Objectives /benefits of a plant nursery:

- Facilitates careful tending of plants at a young stage

- Allows use of small space and saves labour during unproductive stages
- Protects plants from harsh field conditions e.g. strong sunshine, hailstorms etc.
- Allows transplanting of plants to the field when large enough to survive relatively harsh conditions e.g. when soil is prone to weeds direct sowing would lead to smothering of young plants.
- Facilitates high vigor by growing in small, well-fertilized media.
- Allows selection of uniform plants which will mature at the same time
- Some plant species produce very fine seeds, e.g. Eucalyptus spp that is not possible to be sown directly to the field.
- for seeds to germinate uniformly, and seedlings to grow vigorously. During the early establishment young seedlings of most tree species need shade, it is possible only in the nursery.
- Crop grown by nursery raising is quite early and fetch higher price in the market, so economically more profitable
- There is saving of land and labour as main fields will be occupied by the crops after 1 month. More intensive crop rotations can be followed.
- More time is available for the preparation of main field because nursery is grown separately.
- As vegetable seeds are very expensive particularly hybrids, so we can economize the seed by sowing them in the nursery

2. Site selection and preparation

Considerations in selecting a site for a plant nursery-

- Located in an area climatically suitable for the species being propagated
- Near a source of water- The continuity of water supply is essential for seedling production in the nursery
- Should be accessible by all-weather roads-good accessibility,
- It should be located away from tree shade and strong run off channels- no extreme condition (very hot, very cold, strong wind, dry or flooding etc.), and if possible close to the planting sites
- Most nursery plants are grown in a mixture of materials. The site should be accessible to a source of good growing mixes.
- the area is relatively flat, good accessibility,
- Area selected should be well drained, and free from water logging
- There should be proper sunlight,
- - Close to planting area
- - In a secured area
- - Lightly shaded and sheltered area

The area should be well protected from pet and wild animals

3. Types of nurseries and nursery preparation-

For the purpose of this manual, we will classify nurseries into 3 types based on the intended agronomic use:

- Vegetable nurseries- This involves all nurseries for vegetable crops. The nursery establishes vegetable crop seedlings to be transplanted in the main farm.
- Fruit nurseries- This involve a pure stand of various fruit seedlings in a nursery.
- Tree nurseries

Characteristics of good media for nursery establishment

A good nursery substrate has the following characteristics:

- Should be light in weight and easy to transport but heavy enough to hold cuttings and seedlings firmly in place and does not

swell or shrink in away that may damage the plant.

- Good water holding capacity, aeration and drainage
- Free from weed seeds, nematodes and other pathogens
- Adequate fertility (should contain all necessary nutrients for plant growth and development)
- Readily available
- Relatively inexpensive

Below is a list of basic equipment needed for a standard nursery.

- Working the soils: hoe, spade, rake, and shovel
- Soil preparation: sieve
- Watering: watering can/hose with nozzle
- Transport: wheelbarrow
- Grafting: knives, binding tape, sharpening stone, pruner and budding
- Crop protection: Pesticides, Disinfectant

Nursery preparation

Nurseries can be established in form of:

- Seed beds(raised or sunken)
- Movable beds (Flats), Seed boxes
And containers

- **Raised nursery beds**

These are suitable in rainy areas to allow for free drainage of water from the beds.

- Since the seeds are very small in size, they are normally sown in raised nursery beds and the seedlings are planted in the main field later on
- Raising of plant seedlings requires fertile and healthy soil.
- Preferably, the soil for nursery should be loam to sandy loam, loose and friable, rich in organic matter and well drained.
- Select site and clear grasses and weeds
- Measure 1metre wide and any length – should be east to west oriented to facilitate light penetration, minimize effects of heat and to welcome light rays
- Loosen the soil 1 feet deep and pour 1 wheelbarrow of well decomposed and fine compost per every 3 meters and mix well

in the soil. If the soil is heavy mix 4 spades per every 3 meters so that the seed emergence may not be hampered.

- The length of the bed may be kept 3 to 5 meter; however, width is restricted to 1 meter only which facilitates intercultural operations. The beds are raised 15 to 20 cm high from the ground level. A space of 30 - 40 cm is left in between two beds.
- The space between two beds helps in weeding, nursery care against diseases and insect pest and also for draining out the excess rain water from the nursery beds
- Rake the bed into a uniform size
- Make drills or furrows across the bed at 10 – 15cm apart
- Spread seeds thinly and cover with a thin layer of soil
- Beds are firmed by palm after sowing to ensure close contact between soil and seeds
- Water after firming
- Mulch after first watering

- **Sunken nursery beds**

These are suitable in dry areas where water supply to the nursery bed is critical:

- Beds are laid below ground level at least 10 –15cm below the ground level. They should have a drainage system to avoid water logging in rainy seasons.
- Dig and remove soil about 1feet, lay small stones, mix soil with manure and return

- **Movable Beds (Flats), seed boxes and containers**

If the seedlings are to be raised in movable beds/boxes during un-favourable weather condition, the flower pots, polythene bags, potting plugs, wooden boxes, earthen pots etc. may be used.

The best size of the container is 3” deep, 14” wide and 19”- 23” long. The bottom slats should be spaced ¼” apart to allow drainage and aeration.

Prepare media mixture in the ratio of 4 spades compost, 3 spades soil and 1 spade of compost and

fill the mixture in these containers. Arrangement should be made to drain excess water from these structures by making a hole/slats in the bottom of all types of containers

Filling the bed – Lay down ¼” layer of leaf mulch/straw. Fill the flat with moist soil mixture firm gently and level with a piece of timber. Water it a day before sowing seeds

4. Preparation of planting material

Methods of propagation

A. Seed propagation (sexual production)

This method mainly uses seeds as the propagation material. There are two types of seeds based on the need for treatment to break dormancy

- Recalcitrant seeds -do not need special treatments prior to sowing
- orthodox seeds-need treatment to break dormancy before raising them in a nursery bed.

Sexual reproduction by seeds provides opportunity for variation and evolutionary advancement.

B. Clonal (or asexual/vegetative) propagation

The concept of vegetative propagation is that an exact copy of the genome of a mother plant is made and continued in new individuals. This is possible because plants have meristematic-undifferentiated cells that can differentiate to the various organs necessary to form a whole new plant. A piece of plant shoot, root, or leaf, can therefore, grow to form a new plant that contains the exact genetic information of its source plant.

vegetative propagation aims at the identical reproduction of plants with desirable features such as high productivity, superior quality, or high tolerance to biotic and/or abiotic stresses, and as such, plays a very important role in continuing preferred trait from one generation to the next.

The most important vegetative propagation techniques for plant species are the propagation by cuttings, layering, budding, grafting and

micro propagation. The most important reasons for vegetative propagation are:

- Maintaining superior genotypes
- Problematic seed germination and storage
- Shortening time to flower and fruit
- Combining desirable characteristics of more than one genotype into single plant.
- Controlling phases of development.
- Uniformity of plantations.

Forms of vegetative propagation

- **Cuttings**

Cuttings are severed plant pieces with at least one node. Various plants organs can be used for cuttings: stem, shoot, root or leaf cuttings. Plant propagation by cuttings can yield a high multiplication rate and produces plants with their own root system. Examples of crops established through cutting include: sugarcane, cassava, pineapple etc

- **Air layering or marcoting**

The term air layering or marcoting is used for all types of propagation in which roots are formed while the stem is still attached to the mother plant. Only after the root formation, the layer is detached and planted as a new plant.

Air layering or marcoting can be done with almost any woody plant and is an excellent method to propagate small numbers of individual fruit trees/trees. Examples plants propagated through layering include – ficus, azalea, lilac etc

- **Grafting-**

This is joining of two related plants by use a root stock and a plant scion with desired plant characteristics. The Connection (joining) between root-stock and scion should be accurate to make the grafting successful. Accuracy of the connection is determined by the success in joining the cambium of root-stock and that of scion. There are different types of grafting such as wedge grafting, cleft grafting, bark grafting, splice grafting, approach grafting, bridge grafting, inarch, whip and tongue grafting, saddle grafting. Examples plants propagated through grafting include apple, mango, citrus, etc

- **Budding**

In principle budding is attaching auxiliary bud to branch or stem which is desired from a rootstock. Budding techniques include: T-budding, chip budding, Examples plants propagated through budding include citrus, peach, apple, pear etc

- **Micro-propagation or tissue culture**

Micro-propagation or tissue culture are terms used for procedures to propagate plants from plant cells, tissues or organs under aseptic conditions in a controlled artificial environment.

- **Wildlings as planting materials**

In many cases utilizing wildlings as planting materials is more visible than using seeds. This is true for trees with recalcitrant seeds where storing seeds is not possible without losing seeds viability, and also the tree has ability to regenerate naturally.

5. Nursery management practices

1. **Security** -Area of the nursery should be fenced with entry points kept to a minimum
 2. **Bed cover-** After seed sowing the seed that are sown either by broadcast method or line sowing method required cover for better emergence.
- **Use of mulch-**To maintain the soil moisture for seed germination cover the seed bed with a thin layer of mulch or any organic mulch during hot weather and by plastic mulch (plastic sheet) in cool weather. It has following advantages:
 - It maintains the soil moisture and temperature for better seed germination.
 - It suppresses the weeds.
 - Protects from direct sunlight and raindrops.
 - Protects against bird damage.
 - **Removal of mulch-**Due attention is given to remove the covered mulch from the seedbed. After three days, observe the seed beds daily.
 - **Use of shedding net-**After seed germination during the seedling growth, if there is very high temperature (> 30° C) then beds should be covered by 50% or

60% shedding nets about 60 – 90 cm above ground by the use of suitable support.

3. Watering

Watering is commonly conducted twice a day, i.e. at 06.00-09.00 o'clock and at 16.00-18.00. Watering is done by using sprinklers or manually. The size of water droplets should be kept as fine as possible to avoid disturbance to germinating seeds.

The nursery beds require light irrigation with the help of rose can till the seeds get germinated.

Excess rainwater or irrigated water should be drained out from the field as and when it is required otherwise plants may die due to excess of water.

Watering in the beds depends upon the weather condition. If temperature is high, open irrigation is applied. Need not to irrigate the beds during rainy days. The size of water droplets should be kept as fine as possible to avoid disturbance to germinating seeds.

4. Thinning -It is an important operation to remove weak, unhealthy, diseased, insect pests damaged and dense plants from the nursery beds keeping distance of about 0.5 to 1.0 cm from plant to plant.

The thinning facilitates balance light and air to each and every plant. It also helps in watching the diseased and insect pest attacked plants while moving around the nursery.

5. Pricking out – Transplanting small seedlings to a new seedbed to give them more room. Done at two leaf stage e.g. onions

6. Weed control

- Timely weeding in nursery is very important to get healthy seedling. If there are some weeds in the seed bed, remove them manually either by hand or by hand hoe

7. Potting or transplanting - Transplanting of germinating seeds are started when the seedling has already had two leaves

8. Prevention and control from pests and diseases- use fertile soil, crop rotation, maintain hygiene, use natural remedies, avoid congestion of seedlings and damp conditions.

9. Fertilization – Use compost manure while sowing

10. Hardening-off -Hardening-off -Any treatment that makes the tissues firm to withstand unfavorable environment like low temperature, high temperature and hot dry wind." This is needed to train the seedlings to adapt to adverse condition in the planting sites. In this process seedlings are given some artificial shocks at least 7-10 days before uprooting and transplanting. These shocks includes

- Exposure to the full sunlight
- Removal/ opening shading nets of all the shedding nets, polythene sheets
- Irrigation is stopped slowly and slowly-reducing watering intensity.
- cutting the overgrown roots,
- opening shading nets, and no fertilizer application.

11. Transplanting

- If possible transplant in the afternoon or during cloudy days
- Water seedlings before uprooting and remove seeds with damp soil around their roots and do not leave them lying for too long
- Water the holes before transplanting
- Prune the roots if too long. Place the seedlings in the hole and pack the soil around it and firm gently
- Water the transplanted seedlings well to settle the soil
- During dry weather, temporary shade can be provided around the transplanted seedlings

NB: Do not transplant too mature seedlings

References:

1. Sustainable agriculture; practices and technologies, Guidelines for farmers

CHAPTER 10:- PRINCIPLES AND PRACTICES IN CROP PRODUCTION

1. Introduction to crop production

Crop production is a core business for the majority of agricultural holdings world-wide and is the sole source of income for many growers.

Sustainable crop production is a way of growing or raising food in an ecologically and ethically responsible manner. This includes adhering to agricultural and food production practices that do not harm the environment, that provide fair treatment to workers, and that support and sustain local communities.

In addition, sustainable crop production practices can lead to higher yields over time, with less need for expensive and environmentally damaging inputs. A number of different principles are involved in sustainable crop production, including:

- a) Multi-cropping
- b) Minimal to No Pesticide use
- c) Focus on Soil Health

Other Methods of sustainable agricultural practices that focus on growing food sustainably in ways best suited to a particular location or environment, include:

- Aquaponics: Raising aquatic animals such as fish in a symbiotic environment with hydroponically grown plants.
- Agroforestry: A type of intercropping that involves growing trees and shrubs alongside crops to the mutual benefit of both.
- Permaculture: An agricultural philosophy that combines several agricultural principals, including agroforestry, intercropping, mulching, and rainwater catchment.
- Rooftop farms and other methods of urban agriculture: Bringing food production closer to

communities by growing on city rooftops, in small backyard plots, and in vacant lots.

2. Crop classification

Importance of classifying the Crop Plants:

- To get acquainted with crops.
- To understand the requirement of soil & water different crops.
- To know adaptability of crops.
- To know the growing habit of crops.
- To understand climatic requirement of different crops
- To know the economic produce of the crop plant & its use.
- To know the growing season of the crop
- Overall to know the actual condition required to the cultivation of plant.

Crops can be classified in many forms

Forms of classification

a) Crop Classification based on Botanical

System-• The botanical system is a binomial system; two names are used to describe the plant and is otherwise known as the scientific name. • The scientific name is composed of the genus and the specific epithet (or species):
Solanum tuberosum

b) Crop Classification based on important Crop Families

- Poaceae – grass family - Small grain cereals (wheat, barley, oats), corn, rice, sugar cane, forage and turf grasses.
- Fabaceae – The legumes are a large family, important to farms as nitrogen fixers. Peas, beans, soybean, peanuts, cowpeas, lentils and forage legumes (alfalfa, clover), are common vegetables in the legume family. Gardeners

who use clover or alfalfa as cover crops in winter will need to rotate them along with other members of this family, since they are also legumes and susceptible to the same diseases

- Liliaceae – the onion family include onions, garlic, chives, shallots or asparagus- these members of the onion family require rotation just like other families. Although asparagus must be left in place for several years, when selecting a new site for asparagus beds, make sure that no other family members have been grown nearby for several years
 - Apiaceae – carrot family – carrot, celery.
 - Asteraceae – sunflower family – sunflower, lettuce.
 - Solanaceae—these include tomatoes, peppers (sweet and hot), eggplants, tomatillos and potatoes (but not sweet potatoes). Verticillium and fusarium wilt are common fungi that build in the soil when nightshades are planted in the same spot year after year.
 - Brassicaceae – Also known as the cole crops, members of the mustard family tend to be cool season plants. They include: Broccoli, cauliflower, cabbage, canola, kale, Brussels sprouts, radishes, turnips and collard greens.
 - Cucurbitaceae—these are vining plants of the gourd family, or cucurbits, may not seem similar enough to be so closely related at first glance, but each and every member produces their fruits on a long vine with seeds running through the center and most are protected by a hard rind. Cucumbers, zucchini, squash, pumpkins, melons and gourds are members of this very large family cucurbit family
 - Chenopodiaceae – goosefoot family – sugar beet, garden beet,
 - Malvaceae – mallow family – cotton, Okra
 - Lamiaceae – mint family – they include Members such as mints, basil, rosemary, thyme, oregano, sage and lavender. They are sometimes inter-planted with vegetables to deter pests
- c) **Classification based on climate:**
- **Tropical:** Crops grow well in warm & hot climate. E.g. Rice, sugarcane, etc

- **Temperate:** Crops grow well in cool climate. E.g. strawberry, apples, onion, cabbage, Oats, Potato etc.

d) **Based on use/agronomic classification:**

- **Grain/cereal crops:** may be cereals as millets cereals are the cultivated grasses grown for their edible starchy grains. The larger grain used as staple food is cereals. E.g. rice, wheat, maize, barley, and millets are the small grained cereals which are of minor importance as food.
- **Pulse/legume crops:** seeds of leguminous crops plant used as food. They are rich in protein. E.g. green gram, black gram, soybean, pea, cowpea etc
- **Oil seeds crops:** crop seeds are rich in fatty acids, are used to extract vegetable oil to meet various requirements. E.g. Groundnut, Mustard, Sunflower, Sesamum, linseed etc
- **Forage Crop:** It refers to vegetative matter fresh as preserved utilized as food for animals. Crop cultivated & used for fodder, hay, silage. eg- sorghum, elephant grass, guinea grass, etc
- **Fiber crops:** crown for fiber yield. Fiber may be obtained from seed. E.g. Cotton, steam, jute, sun hemp, etc
- **Roots crops:** Roots are the economic produce in root crop. E.g. sweet, potato, sugar beet, carrot, turnip etc.
- **Tuber crop:** crop whose edible portion is not a root but a short thickened underground stem. E.g. Potato, elephant, yam.
- **Sugar crops:** the two important crops are sugarcane and sugar beet cultivated for production for sugar.
- **Starch crops:** grown for the production of starch. E.g. tapioca, potato, sweet potato
- **Herbicidal crops:** used for preparation for medicines. E.g. tobacco, mint, pyrethrum.
- **Spices & condiments/spices crops:** crop plants as their products are used to flavor taste and sometime color the fresh preserved food. E.g. ginger, garlic, chili, cumin onion, coriander, cardamom, pepper, turmeric etc
- **Vegetables crops:** may be leafy as fruity vegetables. E.g. Brinjal, tomato.

- **Green manure crop:** grown and incorporated into soil to increase fertility of soil. E.g. sun hemp.
- **Medicinal & aromatic crops:** Medicinal plants includes, opium poppy, and aromatic plants such as lemon grass, mint, peppermint, rosemary, jasmine, etc.

e) **Classification based on life of crops/duration of crops:**

- **Seasonal crops:** A crop completes its life cycle in one season- E.g. rice, wheat etc.
- **Two seasonal crops:** crops complete its life in two seasons. E.g. Cotton, turmeric, ginger.
- **Annual crops:** Crops require one full year to complete its life in cycle. E.g. sugarcane.
- **Biennial crops:** which grows in one year and flowers, fructifies & perishes the next year? E.g. Banana, Papaya.
- **Perennial crops:** crops live for several years. E.g. Fruit crops, mango, guava etc

f) **Classification based on root system:**

- **Tap root system:** The main root goes deep into the soil. E.g. Cotton etc.
- **Adventitious/Fiber rooted:** The crops whose roots are fibrous shallow & spreading into the soil. E.g. Cereal crops, wheat, rice etc.

g) **Classification based on economic importance:**

- **Cash crop:** Grown for earning money. E.g. Sugarcane, cotton etc
- **Food crops:** Grown for raising food grain for the population and & fodder for cattle. E.g. wheat, rice etc.

h) **Classification based on No. of cotyledons:**

- **Monocots or monocotyledons:** Having one cotyledon in the seed. E.g. all cereals & Millets.
- **Dicots or dicotyledonous:** Crops having two cotyledons in the seed. E.g. all legumes & pulses.

i) **Classification based on photosynthesis' (Reduction of CO₂/Dark reaction):**

- **C₃ Plants:** Photo respiration is high in these plants C₃ Plants have lower water use

efficiency. The initial product of C assimilation in the three 'C' compounds. The enzyme involved in the primary carboxylation is ribulose-1,-Biophosphate carboxylose. E.g. Rice, soybeans, wheat, barley cottons, potato.

- **C₄ plants:** The primary product of C fixation is four carbon compounds which may be malice acid or acerbic acid. The enzymes responsible for carboxylation are phosphoenol Pyruvic acid carboxylose which has high affinity for CO₂ and capable of assimilation CO₂ event at lower concentration, photorespiration is negligible. Photosynthetic rates are higher in C₄ than C₃ plants for the same amount of stomatal opening. These are said to be drought resistant & they are able to grow better even under moisture stress. C₄ plants translate photosynthates rapidly. E.g. Sorghum, Maize, napter grass, sesame etc.

- **Cam plants:** (Cassulacean acid metabolism plants) the stomata open at night and large amount of CO₂ is fixed as a malice acid which is stored in vacuoles. During day stomata are closed. There is no possibility of CO₂ entry. CO₂ which is stored as malice acid is broken down & released as CO₂. In these plants there is negligible transpiration. C₄ & cam plant have high water use efficiency. These are highly drought resistant. E.g. Pineapple, sisal & agave.

j) **Classification based on length of photoperiod required for floral initiation:**

Most plants are influenced by relative length of the day & night, especially for floral initiation, the effect on plant is known as photo-periodism depending on the length of photoperiod required for floral ignition, plants are classified as:

- **Short-day plants:** Flower initiation takes place when days are short less than ten hours. E.g. rice, green gram, black gram etc.
- **Long day's plants:** require long days are more than ten hours for floral ignition. E.g. Wheat, Barley,
- **Day neutral plants:** Photoperiod does not have much influence for phase change for these plants. E.g. Cotton, sunflower. The rate of the flowering initiation depends on how short or long is photoperiod. Shorter the days,

more rapid initiation of flowering in short days plants. Longer the days more rapid are the initiation of flowering in long days plants

k) Crop Classification based on Plant habit

- Determinate Crops – Flowering is confined to a specific period of time in these crops, at the end of vegetative growth.
- Indeterminate Crops – Flowering is continuous and not confined to a specific period in these crops, as flowering overlaps with vegetative growth.

3. Land preparation and tillage techniques

Land preparation is one of the most laborious activities performed during crop husbandry.

Advantages of Good Land Preparation

- Kills harmful insects inhabiting in the soil. By digging into the land, some harmful insects and/or eggs that normally live inside the soil will be exposed to the sun and either weakened or killed by the heat and/or by birds that feed on insects;
- Kills weeds and weed seeds. Some weeds that have deep roots and/or remain under the soil will be brought to surface and will be killed by sun/heat;
- Seeds will germinate evenly and quickly;
- Young plants will have good growing conditions, enabling their roots to grow deeper into the soil, to draw more water and absorb plant foods

These are the soil management practices, which seek to increase the depth of cultivation, reduce labor and make easy penetration of roots, water and reduce soil erosion.

Soil tillage techniques

Deep digging, Double digging, 5/9 maize seed holes, Portable garden, Raised bed, sunken bed, Fertility trench, Mandala garden, Key hole

Deep digging

This is a technique that can be used on the farm to increase production. It involves digging deeply

into the ground. The technique encourages farmers to dig 1 ft or 30m deep in the ground while mixing the soil with manure. This break the hard pan created by shallow digging and allows crops roots to penetrate deeper. Deep digging also makes the soil to drain easily and improves water retention. It also enables soil aeration and reduces soil erosion.

Double Digging

Double digging is intensive tillage technique suitable for small scale farmers. It involves removing the top soil, mixing it with compost, then loosening and digging the sub soil to break the hard pan if present and facilitate root growth.

The purpose of double digging is to create a deep layer of top soil mixed with manure/compost for easier root penetration, water retention and aeration. The technique allows for intensive growing of crops. It also allows close spacing of crops as the beds are well fertilized increasing productivity.

Procedure

- Select the place to prepare double dug beds
- Measure 24ft length and by 3ft width
- Measure 3ft stretch on the bed and peg markings
- For each 3 ft stretch pour 1 wheelbarrow of compost/manure
- Using a fork, spread the compost/manure on the bed
- Starting from one side of the bed, dig 1 ft of the top soil as you mix it with manure.
- Take top soil and compost from the first stretch and put it in a wheelbarrow to take it to the end of the bed.
- Break hard pan sub soil preferably one foot deep- to make it loose. When done, level the sub soil level, you may apply some compost or manure.
- Collect some dry materials, green vegetation and put them in the hole above the sub soil.
- Fill the first hole with the top soil compost from the second trench
- Use a rake to level the finished bed
- Mulch the double dug

Note. You can make a raised double dug bed or a sunken double dug bed.

5- 9 seed hole

This is a form of technique that allows loosening of the soil 2ft deep facilitating harvesting of water and enriching the top soil.

- Measure 2ft x 2ft
- Dig top soil and keep aside
- Dig out subsoil 1ft deep and keep aside
- Pour 1 debe of compost/manure and mix it with the top soil.
- Put the mixture of top soil and manure back to the hole. Add some sub soil mixed with manure if necessary on top.
- The rest of the top soil is less fertile and is embanked on the sides of the hole to improve on water harvesting.
- Mulch the hole and move to the next hole preparation.

Raised beds

These are seedbeds which are raised about 15cm from the ground level

Preparation

- Select site and clear grasses and weeds
- Measure 1metre wide and any length – should be east to west oriented to facilitate light penetration, minimize effects of heat and to welcome light rays
- Loosen the soil 1 feet deep and add manure (one wheelbarrow) for every 1 metre and mix well

In a raised-bed garden, soil is dug and improved and more soil is added, creating a long and narrow hill upon which the plants are grown

Raised-bed gardens can be damaging in hot, dry environments, as they can increase already dry conditions

Sunken beds

Beds are laid below ground level –at least 10–15cm below ground level. They should have a

drainage system to avoid water logging in rainy seasons.

Dig and remove soil about 1feet, lay small stones, mix soil with manure and return

While many gardeners across the country are familiar with raised-bed gardening, they may not know much about the opposite technique, sunken gardening or basin gardening. Both gardening methods are used in response to otherwise challenging environmental factors, but one cannot be substituted for the other. If a raised-bed garden makes no sense in your environment, a sunken-bed garden might be exactly what you need

In the opposite sunken-bed garden, topsoil is dug and set aside, then deeper clay soil is dug and used to create hills in between the rows. The topsoil is then returned to the trench along with soil amendments such as compost and peat. Plants are grown in the trench while the hills in between shelter the rows.

Portable/Multistorey gardens

It is simple, labour saving and attractive to the eyes. Portable kitchen gardens can be erected around farm houses. Farmers are able to grow vegetables, organically for their kitchen needs such as kales, spinach and tomatoes intercropped with pests repellent plants.

Materials: top fertile soil, manure/compost, sacks, gravel/small stones and empty Kasuku oil tins with top and bottom sides open,

How to make it:

- Identify leveled sites around to place the sack.
- Mix the top fertile soil well with well-prepared compost.
- Fold your sack up to 1ft and fill it with the mixture
- At the centre of an open bag, place the Kasuku tin/or hollow pipe on the soil mixture.
- Fill the Kasuku tin with stones.

- Carefully fill the mixed soil to the height of the tin.
- Slowly and gently pull up the tin to the level of the soil in the bag.
- Fill the tin with stones and repeat the same with soil.
- The upright standing bag is now full to the top.
- Pour water gently on the stones and soil is made wet from top to the bottom.
- Using a sharpened stick the size of your thumb, pierce well-spaced holes all round the bag from top to bottom. Into these holes, gently plant your vegetables and add water.
- A three to six month's sustainable kitchen garden is ready. It requires less water, no cultivation and no labour. To scare birds and chicken from eating leaves and fruits; slurry from cows, goats and sheep can be applied on the open top of the bag and outside.

Fertility trench

This is a form of water harvesting and fertility improvement whereby a trench measuring 2ft wide and with any length is dug separating the top soil and sub soil.

Procedure

- Measure a trench 12ft (length) by 2ft (width)
- Dig out the topsoil and keep it aside
- Dig out subsoil and keep it aside
- Lay dry materials- this improves the aeration of the trench
- Lay green vegetation
- Mix animal manure/compost with top soil - for every 3ft of trench, add a bucket of compost.
- Put the mixture of top soil and compost back to the trench
- The sub soil is embanked round the trench as it will aid in water harvesting to the trench.
- Sprinkle ash
- Mulch the trench

One can plant maize, arrow roots, kales, spinach etc in the trench

Arrow root trench

This is an improved fertility trench by use of a polythene sheet at the base and sides of the trench. There are polythene sheets with 7ft width and are able to make a trough and ½ ft left on both sides. It is advisable to buy 5ft more than the length of the trench to allow covering the depth of the trench at the edges and about ½ ft sheet is left outside the trench.

Compost is added to the soil to improve its fertility and structure .

There-after, arrow roots are planted in the trench with a spacing of 30cm, the trench acts like a trough harvesting and storing a lot of water.

The trench produces arrow roots for the homestead, vegetables (arrow root leaves) as well as beautifies the compound.

4). Planting and cropping systems

Sustainable crops are grown in a different manner from industrial crops. Sustainable crop farmers focus on ensuring that their farming practices can be sustained over time and do not cause undue damage to the environment. These include:

1. Mono cropping

This involves growing of individual crop or one type of crop in the farm

Advantages:

- Easy to weed (it is possible to mechanize farming)
- Easy to control pest and disease

2. Multi-cropping

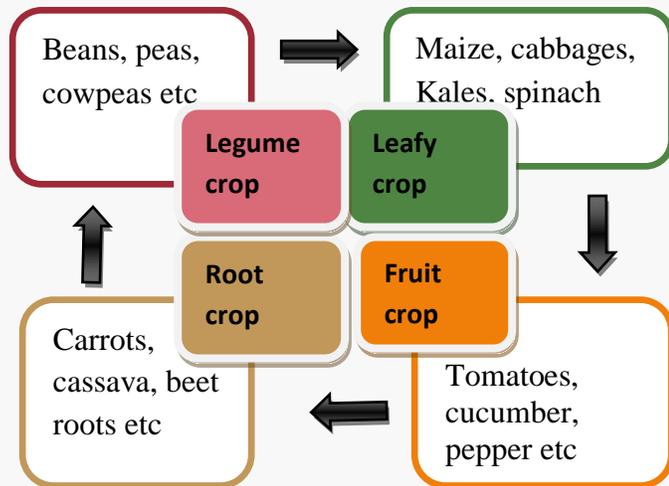
Multi-cropping is an agricultural method of planting multiple species on one piece of land, either during the same growing season or in successive growing seasons. Multi-cropping can involve:

- **Crop rotation:** the practice of changing what is planted in a particular location on a farm from season to season.

This is changing of crops seasonally. The farm is always divided into plots and crops are rotated after every harvest.

Rotating crops is one of the most basic techniques gardeners and farmers can use to assure plant crop success. Everyone farmer should consider rotating their crops, because it helps maximize productivity while minimizing pests and disease.

A sample crop rotation cycle



In crop rotation pattern, the most important consideration is the supply of plant nutrients.

- Leguminous crops: Beans and peas are said to be nitrogen-fixing because they pull nitrogen from the air and store it in their roots. So they follow the roots and insure there'll be lots of nitrogen available for the next leaf rotation. They fix nitrogen in the soil through their root nodules and improve soil fertility e.g. beans, peas, dolichos lablab (njahi), cowpeas (thoroko), etc
- Leafy crops (Heavy feeder) - The leaf group contains all the big nitrogen dependent crops like lettuce, greens, herbs, spinach, and the brassicas (cabbage, broccoli, cauliflower, brussel sprouts, and kale). They need lots of nitrogen to grow strong leaves and stems but nitrogen is the hardest nutrient to keep in the soil. That's why they follow the nitrogen fixing legumes in the rotation.
- Fruit crops (Moderate feeder): The fruit crops include tomatoes, cucumbers, peppers, eggplant, and squash. These plants need phosphorus to set blossoms and develop fruit,

but shouldn't get lots of nitrogen or they'll make all leaves and no fruit. Technically, maize is a fruiting crop but it's exceptionally grown in the leaf group because it does need lots of nitrogen.

- Root crops - Light feeder: Onions, garlic, turnips, carrots, beets, and radishes are all root crops that need potassium but don't need much nitrogen. So, the roots follow the fruits since there's little nitrogen left at this point in the rotation. Note-Potatoes are root crops to plant them with the fruit because they are they're members of the solanaceae family and suffer from the same pests as tomatoes, peppers, and eggplant.

Summary

The crop rotation system breaks the crops into four groups based on their nutritional needs:

- Leaf (nitrogen).
- fruit (phosphorus),
- root (potassium), and
- Legume (fixes nitrogen).

In this system, the leaf plants go where legumes were last year, because legumes fix nitrogen in the soil, and leaf plants need large amounts of nitrogen. The fruits follow the leaf plants because they need phosphorus, and too much nitrogen causes them not to have fruits. The roots follow the fruits because they need potassium and need nitrogen less than the fruits. Finally, the legumes follow the roots to put nitrogen back into the soil

Crop rotation is important in crop production because:

- ►It avoids disease attack on crops in the previous plot.
- ►It adds nitrogen in the soil by growing legume crops.
- ►It prevents soil erosion by growing dense (foliated or vined) crops such as snake beans.

- ▶Varieties of crops are grown for the farmer's use.
- **Intercropping:** a method of planting two or more crops of differing characteristics in close proximity to reduce weeds; to encourage plant diversity in order to avoid insect and pest infestation; and to provide shade, nitrogen fixation, or other benefits to the plants being grown. Intercropping includes companion planting and the use of cover crops.
- Some plants release (exude) chemicals from the roots, which stimulate growth of their companions or perhaps protect it from soil pest.
 - Cabbage and Tobacco
 - Cucumber and beans/peas
 - Cucumber and maize
 - Spinach and strawberries
 - Kales and onions
 - Turnips and peas
 - Potatoes and maize
 - Tomatoes and Cabbages

Intercropping and crop rotation can improve soil health by introducing plants that fix nitrogen (a process that pulls nitrogen from the air and releases it into the soil) or plants that can be turned under after their growing season is complete to add additional nutrients to the soil. Crop rotation also generally increases yields, while monocropping has been implicated in declines in crop yield and loss of nutrients from the soil.

Rotating crops allows soil to “rest,” that is, to replenish its vital micronutrients, microbes, and other important components.

- **Companion Planting**

This system offers a considerable degree of preventive protection, which occurs naturally for the following reasons:

- Some plants produce aromatic smell, which confuse pests from discovering their food. Plants like onions; Mexican marigold act as repellants therefore reduces the spread and prevalence of pests.
- Biological pest control will occur because pest-to-pest control will take place i.e. pest that affects beans will attack pests that affect maize and vice versa.

Examples:

- Mixture of maize and beans reduces infestation from armyworm.
- Tomatoes planted in rows between cabbages reduce damage by the diamond black moth.
- Potatoes planted in conjunction with onions, beans, and Soya beans reduce damage caused by potato tuber moth.

Plants for Companion Cropping

The plants include: Onions, beans, maize, Mexican marigold, nasturtium, tobacco, stinging nettle, hot pepper, cowpea, potatoes, cabbages, kales, sesbania sesban, caliandra, desmodium, etc.

This is planting of crops which are beneficial to each other e.g. maize and beans, kales and onions, etc. Maize helps the beans with shade and acts as windbreaks, while beans benefit maize with nitrogen fixation. Kales helps the onions by covering them while onions act as repellants thus they control pests and diseases.

Advantages of companion planting

- The crops supplement one another with nutrients
- They help in the control of pests and diseases since some plants acts as repellants e.g. onions

Multi-cropping is in direct contrast to monocropping, in which large tracts of land are planted with a single crop.

Multi-cropping contributes to a number of environmental benefits, including:

- Increased yields.- Monocropping has been shown to decrease yields over time, while multi-culture practices such as crop rotation and the use of cover crops can increase yields by reducing pests, improving soil health, and increasing water retention.
- Decreased pest susceptibility. Multi-cropping reduces extreme vulnerability to a wide array of pests, including weeds, insects, fungi, and other organisms. The lack of genetic diversity

on mono-cropped farms means that a single pest can decimate large areas of cropland.

- Increased biodiversity. Multi-cropped farms have a number of species that may interact in a meaningful way, such as providing shade for other crops, providing nitrogen fixation for the soil, or repelling pests.

Seed and plant variety selection is an important component of sustainable crop production.. The focus on hybridization and monocropping in industrial crop production has resulted in a loss of biodiversity on farms and a decline in nutrients in a number of different staple crops

While sustainable crop production does not necessarily eschew hybrid varieties, crop varieties are chosen primarily for taste, nutritional content, and adaptability to a particular environment.

Finally, in industrial crop production operations, genetically engineered crop varieties may be grown to control pests, to allow greater application of herbicides, or to conform to perceived consumer demand (*e.g.*, an apple variety that does not brown when cut). However, sustainable ecological agriculture rejects GE varieties due to their potential adverse environmental impacts, the uncertainty of their healthfulness, and the large amount of inputs required for their production (*e.g.*, commercial fertilizers, herbicides, etc.).

5). Field crop establishment and management-

Crop husbandry practices

Crop husbandry deals with the various aspects of crops from seed sowing, on field and off-field operations, harvesting, threshing, storage and marketing of the products. It can be further divided into the following main sub-divisions:

1. Planting/ Transplanting

The time of planting and methods used are very important. Delays in planting can cause farmers

to have poor harvests.

2. Weeding

Weeding is another crucial activity in crop husbandry. To minimize competition from weeds and unwanted plants, farmers should do weeding at various stages of plant growth. Effective weed control is a must for good crop production. Weeds reduce crop yields.

Importance for Weeding

There are several reasons why farmers should do weeding.

- To reduce the competition for plant food, water and sunlight with our crops. The plant food and water needed for plant growth, development and maturity are found in the soil (in varying quality depending on the soil type and other factors). Like our plants, weeds use the food and water from the soil that is being used by our crops. These weeds, once removed, will in healthier plant growth and larger increases in crops yields.
- To improve the quality of the harvest. Weeds produce a lot of seeds. If left in the field during harvest, weed seeds can mix with produce and reduce the quality of the harvest. Weeds are unwanted plants that grow amongst crops in the field. If not weeded, they will produce seeds and can be accidentally harvested with the crops. Some weeds arrive with seeds transported from other areas.

Weeding must be done during early stages of seed growth. It is important to start weeding 2-3 weeks after crop germination. Crop plants will be healthier if weeds are eliminated as early as possible.

Weeds should be removed before they become strong. If farmers fail to weed early or wait too long to begin weeding, weeds can suffocate the crops, depriving them of nutrients and water and causing them to grow weakly, resulting in poor production

When weeds grow tall, they cause trouble during harvesting. Most weeds have seeds and if weeding is not done earlier, they will produce seeds which can easily mix with the crops during harvesting and storage and will actively germinate and grow faster the following year, creating fields full of weeds. This will create problems during land preparation;

Weeding can/should be done 2-3 times prior to harvest depending on the intensity of weeds and crop growth.

3. Gapping/thinning

Thinning involves the removal of part of the crop in order to concentrate future volume growth on fewer and better quality stems. Thinning is especially important to provide good crop spacing. It helps to reduce plants competition for water, nutrients and space which could lead to weak plants. Thinning should be done at first weeding or after first weeding. Thinning under moisture stressed dry soils affects the root system of the remaining plants. Thus, it is recommended that thinning should be done when the soil is moist. Gapping is useful in some crops by transplanting seedlings to fill the space gaps. This is encouraged when thinning is done within 2 weeks after emergence and when the soil is moist.

4. Pest management- pest infestation in crop production can cause high yield losses. Pest management should form an integral part in crop husbandry to prevent and control pest damage in crops

6. Maturity indices of horticultural commodities, harvesting and post harvest handling

Fresh produce must be harvested at the correct stage of maturity if it is to maintain its quality attributes throughout its post-harvest life. Prematurely harvested produce is highly susceptible to shriveling and mechanical damage and it is of inferior flavour and colour when ripe. Over-mature produce may be fibrous, soft and of poor eating quality in terms of sweetness, flavour and colour.

It is, therefore, essential that those involved in harvesting receive training to identify the correct maturity indices for the produce concerned. Furthermore, careful and correct harvest techniques are essential in ensuring the integrity of harvested produce and preventing post harvest losses. Wounding during harvest can provide entry points for pathogens, therefore causing decay. Those involved in harvesting must be trained in efficient and careful handling of fresh produce.

Physiological and commercial maturity- Physiological maturity

– refers to a particular stage in the development of a plant or plant organ. It Refers to the development of an organ (e.g. fruit, leaf) or organism (e.g. ornamental plant). In case of fruit, ripening can be considered the next development stage (senescence stage).

A fruit is physiologically mature when its development is over. A physiologically mature fruit may not necessarily be commercially mature. For example, papayas are harvested for domestic markets at physiological maturity, i.e. when three-quarters of the fruit assumes a yellow to green colour.

Commercial maturity – pertains to the timing of harvest to meet specific market and consumer requirements. A fruit is commercially mature when it reaches a developmental stage at which it can be marketed for a specific purpose, e.g. for consumption in the fresh state, or for processing. Papayas, for example, are harvested for export at the mature stage, i.e. when the fruit is firm and easy to handle. On arrival at the destination the fruit is ripened in ripening rooms. Note that commercial maturity has little impact on physiological maturity.

Maturity indices-

Maturity can be described as the attainment of the particular size or stage after which ripening takes place. On the other hand, ripening means the qualitative changes in fruits after maturity of which it become edible

The maturity index of a fruit provides an indication of its stage of development or

maturation. Maturity indices are based on characteristics that are known to change as the fruit matures. Maturity indices for harvest can be either subjective or objective

Determination of maturity

The stage of maturity at which a fruit or vegetable should be harvested is important for its subsequent quality, storage and marketable life

Determination of maturity can be grouped into physical, chemical, physiological, computation, electronic etc. based on the principles used for measuring the various parameters.

Physical method

- **Skin colour:** change of skin colour of many fruits at maturity (Tomato, Papaya, litchi, mango) colour charts are used for apple, tomato, peach etc. Instruments are also available for measuring colour of fruits and this is mostly used in harvested fruits. As fruit mature and ripen they undergo a colour change from green to red or yellow, for example – papaya The appearance of the colour for certain cultivars, e.g. tomatoes can, in some cases, signal an appropriate time to harvest. Skin colour is not, however, considered the most accurate index of maturity. Sampling of fruit for evaluating maturity
- **Shape:** the shape of fruit and vegetable can change during maturation. Eg.: Banana becomes less angular. Some fruits are considered mature when fruit shoulders well developed and filled out. Similarly, the fullness of the cheeks adjacent to the pedicel in mangoes provides an indication of maturity
- **Size:** Size is frequently used to determine at harvest. It is related to market requirement.
- **Firmness:** As fruits mature and ripen the tissues become soften. The softening can be estimated by the finger feel of commodity (Firmness can be measured by penetrometer).

- **Specific gravity:** It is measured through weight of solids or liquids. As fruits mature their specific gravity increases. This method is rarely practiced.
- **Fruit aroma:** -Volatile compounds synthesized during ripening give fruit their characteristic odour and provide an indication of the level of maturity. Fruit odour is generally detectable by humans when the fruit is completely ripe and is of limited use in commercial situations. Based on this we can determine whether fruit is ripe.
- **Number of days after full bloom** -Days after full bloom can provide an approximate harvest date. This approach relies on a reproducible date for the time of flowering and relatively constant growth period from flowering through to maturity.

Chemical method: a) Sugars, b) starch, c) acidity.

- **Sugar:** As the fruit ripens. Starch is broken down to sugars. Measurement of sugars indicate the stage of maturity or ripeness, sugar constitute the major portion of soluble solid of the fruit juice. Measurement of TSS is done on refractometer.
- **Starch:** Starch content in developing fruit of pear and apple provides harvest maturity.
- **Acidity:** The acidity of many type of fruit changes during maturing and ripening. In citrus, mango, pineapple and many stage other fruits acidity progressively decrease as the fruit matures on the tree.

Physiological methods

Climacteric fruits in which there is a distinct rise in respiration during ripening, can be sampled and kept at high temperature and respiration rate is measured. By this way we can predict the number of days will take for ripening stage if left on the tree.

Climacteric fruit: are harvested at full maturity stage and ripen after harvest. Maximum

respiration starts immediately after harvest. Long shelf life (6-8 days) no need of sophisticated packing material as fruits are hard. Eg: Apple, Apricot, Avocado, Banana, Blue berry, Kiwi fruit, Mango, Papaya, Passion fruit, Peach, Peas, Muskmelon, Watermelon and tomato.

Non-climacteric fruits: Harvested at full ripening (90-95%) complete colour development. Rate of respiration is less than climacteric fruit. They are difficult to transport need sophisticated packing material as fruits are soft and ripened. Eg: Cherry, cucumber, grapes, lemon, pineapple, mandarins etc.

- Computation method

The time required between flowering and fruit being ready for harvesting may be measured by 'heat units' or degree days in a particular environment.

- Electronic and other methods

Electronic colour sorter: used in packing houses to sort-out fruits on the basis of colour. Eg: Apple, orange etc.

vibration test

The sound of fruit when tapped with knuckle of the finger, the sound heard changes during maturation and ripening- Eg: Watermelon and jack fruit.

Ripening

The sequence of changes in texture, colour and flavour as a result of physiological and biochemical change that makes the fruit ready for consumption

Artificial ripening – climacteric fruits are picked relatively green and subsequently ripened by introducing ethylene or acetylene gas (calcium carbide) Eg: Banana, Mango, Pear and Avocado. On the basis of the respiratory pattern and ripening behavior fruits are carried into two classes viz., climacteric fruits and non-climacteric fruits.

Changes occur during maturation and ripening (physiological and Biochemical)

- a. Water: After harvest, during storage and ripening, fruit and vegetable lose water as a result of respiration transpiration and exchange of gas, resulting in water loss. Loss of H₂O depends upon the RH, temperature, anatomical structure and the rate of transpiration and respiration. When the loss is more than 5-10% fruit and vegetable start shrivel and become unusable.
- b. Colour: The most common change is loss of green colour. It is due to degradation of chlorophyll structure. The degradation is due to pH, oxidative systems. The disappearance of chlorophyll is associated with the synthesis of pigments ranges from yellow to red.
- c. CHO: CHO are important in attaining pleasing fruit flavours through sugar to acid balance, attractive colour and whole some texture.
- d. Organic acids: the nonvolatile organic acids are among the major cellular constituents undergoing changes during the ripening of fruits. As the fruit ripens the acid content minimize and converts it in to sugar.
- e. Proteins: Proteins are free amino acids, minor constituents of fruit and not have much role in determining eating quality.
- f) Flavouring compounds: Aroma plays an important part in the development of optimal eating quality of fruit and vegetables. This is due to the synthesis of many volatile organic compounds during the ripening phase.
- g) Enzymes: Many of the chemical and physical effects that occur during ripening of fruits are attributed to enzyme action.

Harvesting.

In order to determine the optimum harvest date within an orchard, a random sample of 20 fruit must be collected from each orchard block, and the soluble solids, firmness and starch content measured:

Manual harvesting is one of the most popular methods of harvesting produce. Farmers must, however, be properly trained if quality is to be

assured. The selection of a harvesting procedure will depend on the produce characteristics.

Advantage of manual harvesting

Manual harvesting remains one of the most popular methods for harvesting produce:

- Pickers can selectively pick if trained properly.
- Selective picking can also ensure that fruit only at its required quality is harvested, i.e. required size, colour, free from defects and diseases.

Basic principles for harvesting

- Harvest good quality crop.
- Maintain hygiene and quality standards during harvesting and throughout the post-harvest chain.
- Harvest during the coolest part of the day – early morning or late evening under light conditions.
- Protect the harvested produce in the field by keeping it in a shaded environment.

How to harvest fresh produce

Vegetables

Either the whole or a part of vegetative growth can be harvested by hands only or sharp knives. Knives must be kept sharp and clean at all times to prevent from spreading virus diseases from plant to plant.

Harvesting methods vary with plant parts harvested:

- leaves only (spinach, kales, etc.) and lateral buds (Brussels sprouts): the stem is snapped off by hand;
- above-ground part of the plant (cabbage, lettuce): the main stem is cut through with a heavy knife, and trimming is done in the field (the cut stem must not be placed on the soil);
- bulbs (green onions, leeks, mature bulb onions): immature green onions can usually be pulled from the soil by hand; leeks, garlic and mature bulb onions are loosened by using a digging fork as for root crops (such as carrots) and lifted by hand.

Flower structures

Immature flower heads (cauliflower, broccoli) can be cut with a sharp knife and trimmed in the field; broccoli can be snapped off by hand and subsequently trimmed.

Fruits

Many ripe fruits and some immature seed-bearing structures, such as legume pods, have a natural break-point of the fruit stalk, which can easily be broken at harvest. Fruit and other seed-bearing structures harvested in the immature or unripe green state are more difficult to pick without causing damage to either the produce or the plant. These are best harvested by cutting them from the plant, using clippers, secateurs or sharp knives. The clippers may be mounted on long poles for tree fruit, with a bag attached to the pole to catch the fruit. Plucking methods vary according to the kind of produce being harvested:

- Ripe fruit with a natural break-point, which leaves the stalk attached to the fruit, are best removed by a “lift, twist and pull” series of movements, e.g. apple, passion fruit, tomato.
- Mature green or ripe fruit with woody stalks that break at the junction of the fruit and the stalk are best clipped from the tree, leaving up to a centimetre of fruit stalk attached. If the stems are broken off at the fruit itself, disease may enter the stem scar and give rise to stem end rot, e.g. mango, citrus, avocado.
- Immature fruit with fleshy stems can be cut with a sharp knife, e.g. zucchini, okra, papaya, capsicum; these can also be harvested by breaking the stem by hand, but this method may damage the plant or fruit and the rough break will be more susceptible to decay than would a clean cut.

Recommended good harvesting procedures

- Use white clean cloth and gloves.
- Use correct clean containers.
- Prevent overfilling.
- Prevent damaging the fruit, dropping the fruit in to the containers at a distance and rough handling.

- Use selective harvesting and correct maturity index.
- Use correct equipment and harvesting techniques.
- Harvesting time and weather conditions.

Harvesting containers

Rigid containers, such as wooden and plastic crates, and plastic buckets can be used for the field collection of harvested produce.

Containers must be smooth, with no sharp edges or projections as these could damage the produce. They must be clean and must not be overfilled. Harvesting bags equipped with either shoulder slings around the neck, or waist slings, can be used for the collection of firm-skinned fruit such as citrus and avocados. They are easy to carry and leave both hands free to harvest. Harvesting bags must be designed to open at the base, so as to allow produce to be emptied easily into a field container without tipping the bag.

Harvested produce

- Must not come into contact with the soil or contaminated surfaces, e.g. surfaces that are visibly contaminated with dirt, oil or chemicals.
- Must not be dropped.
- Must be gently transferred to collection bins and protected from sun or rain until such time that it can be transported to the pack house. Cuts and bruises must be avoided during harvesting operation.

Personnel, participating in harvesting and grading

- Farm workers who are in direct contact with fresh fruit and vegetables must have good habits of body hygiene and wear clean clothes and cover their hair.
- Any farm worker with cuts or wounds, if authorized to continue working, must protect them with waterproof bandages.
- They must wash their hands with soap, before starting harvesting of fruit and vegetables and each time they return to the handling areas after a pause, immediately after having used the toilets and after having handled any contaminated product. It is recommended to brush under nails and between nails, rinse and

dry the hands with the dry towel. The use of shared towels is not advisable.

- Each farm worker must go through hygiene checklist; those who fail hygiene check should be leased to go back home. The state of health of the staff involved in harvesting
- Staffs with health problems involving diarrhoea or open lesions (skin lesions or infected wounds) constitute risk vectors.
- Any person with cuts or wounds must protect themselves in order to avoid any direct contact with the products. A purulent lesion or an infected wound may come into contact with fresh fruit and vegetables or equipment used for their harvesting, and transmit infectious diseases.
- Staff known to carry a certain disease or infection must not be authorized to go into the zone where products are handled. Any person in this situation must immediately inform management of the disease or symptoms.

Personal behaviour during the harvest

- The farm worker must avoid behaviour that can lead to contaminating food, such as smoking, spitting, chewing gum, eating, sneezing or coughing, near non protected fruit and vegetables.
- Personal belongings, such as jewellery, watches or other objects, must not be worn or taken into fresh fruit and vegetable harvesting zones.

Specific harvesting training needs

- The methods of evaluating the readiness of the crop for harvest, and the rejection of unsuitable produce at harvest, according to market requirements.
- The actual technique to be employed in harvesting produce, e.g. Breaking the stem or plucking, clipping, cutting or digging.
- The use of harvest containers and the transfer of produce to field or marketing containers.
- The selection of marketable produce at the field assembly point and (if applicable) grading for size and quality.
- The correct application of post-harvest treatment (where produce is to be packed on

the farm directly into marketing packages), e.g. Fungicides, wax coating.

- The method of packing market packages or other containers.

Temperature management during harvesting

At harvest, the temperature of the fruit is close to that of the ambient air, which varies according to the location and time of year. In order to ensure the lowest possible temperature at harvest, it is generally recommended that fruit and vegetables be harvested during the coolest part of the day, which is usually early morning. Citrus fruits are one exception to this recommendation, given that they are damaged if handled in the morning when they are turgid.

Harvest produce must be retained under shade or in a cool temporary storage area, and must be pre-cooled within the shortest period of time in order to remove the field heat. The use of charcoal cooler for pre-cooling practice

In rural areas where most farmers are not accessible to electricity, it is therefore recommended to use a charcoal cooler for pre-cooling practices. A “charcoal cooler” is made of charcoal between chicken wire mesh, The

charcoal cooler should be designed to ensure that all air passing into the cooler passes through the charcoal (no gaps in the charcoal walls). The charcoal should be kept wet to enhance the cooling effect. This can be achieved using a drip line at the top of the charcoal wall, fed from a water tank on the roof.

Regardless of the cooling method used, care must be taken to assure the cooling medium does not contaminate the produce.

Maintenance of harvesting equipment

All field equipment used in harvesting produce must be cleaned and repaired on a regular basis. Regular cleaning of all harvesting equipment is essential. All harvesting tools must be washed daily in a soap solution and in certain cases, as occurs with heavy soil or sticky substances, a disinfectant such as bleach should be used at recommended concentrations.. Maintaining harvesting equipment makes sound economic sense, because such equipment often reflects considerable investment by the farmer.

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CHAPTER 11: CROP PEST AND DISEASE MANAGEMENT

1. Introduction to pests and diseases in crops

A pest is any organism that hinders the proper growth of a crop and causes reduced production (insects, nematodes, other animals, fungi, weeds, and virus)

From an ecological perspective all organisms are part of nature, irrespective of what they do. To a farmer, all organisms that reduce the yields of their crops are considered pests, diseases or weeds. Insects, birds or other animals are also pests whenever they cause damage to crops or stored produce. Fungi, bacteria and viruses are also recognized as disease causing organisms when they lead to conditions that interrupt or modify the vital functions of growing plants or stored produce. All unwanted plants that grow within crops and compete with them for nutrients, water and sunlight are considered weeds. Such plants can also be hosts for pests and diseases.

Presence of these organisms in crop fields is not a problem until their numbers increase beyond a level where they attack, and cause substantial reduction in field crop yields or quality of harvested and stored produce. Farmers, who wait until this moment, often depend on aggressive and very harmful methods to limit damage. However, since many African small-holder farmers neither have the access nor can afford such methods and products, yield and quality losses are often substantial. In general, challenges associated with pest, disease and weed management can be summarized as follows:

- Wide diversity of pests, diseases and weeds- In sub-Saharan Africa a wide variety of pests, diseases and weeds occur because of the favourable, humid conditions nearly

throughout the year. Because of this, many new pests, diseases and weeds evolve or are introduced, mostly accidentally, in the region. It, therefore, proves very challenging for farmers to recognize, distinguish and control the different pests, diseases and weeds.

- Poor monitoring- Many farmers lack knowledge on the cycles of specific pests, diseases and weeds and find it difficult to distinguish their specific characteristics. As a result, they cannot apply suitable preventive measures nor implement proper control measures.
- Limited access to pesticides- The great majority of African farmers lack the financial resources to buy chemical pesticides to control pests, diseases and weeds.
- Limited knowledge on suitable pesticides- There is a wide variety of pesticides available on the market, including ineffective ones. Since the majority of farmers cannot read and interpret the contents, prescriptions and other precautions, they cannot make proper choices on the best pesticides. They instead rely on recommendations from the pesticide retailers, who often lack the proper knowledge themselves and are often more motivated to make sales than advise farmers.
- Lack of knowledge on proper storage and application of pesticides -Farmers are exposed to high health risks in the case of improper application of pesticides; for example, the majority lack appropriate protective gear. In addition, synthetic pesticides and application equipment are usually stored inside homes, where food and children are exposed to them. Also, treated crops are sometimes harvested without proper

observation of pre-harvest intervals, thereby exposing consumers to greater health risks. This is a clear indication that the management of pests, diseases and weeds is still very challenging to many farmers all over Africa. To avoid major crop losses, the farmers should be able to implement affordable and effective measures which should not substantially increase their production costs

or harm beneficial organisms in the ecosystem.

Generally appropriate methods and products should be:

- Easy to apply at minimal extra cost.
- Applicable in the local situation and conditions.
- Safe to handle, with minimal or no residual effect

2. Identification of common pests and diseases in crops

 African armyworm	 African bollworm	 African maize stalk borer	 Aphids	 Bagrada bug
 Banana Weevil	 Cabbage looper	 Cabbage moth	 Cabbage webworm	 Cowpea seed beetles
 Cutworms	 Diamondback moth (DBM)	 Fruit flies	 Larger grain borer	 Leafminers
 Whiteflies	 Mango seed weevil	 Mealy bugs	 Sweet potato weevil	 Termites

 Spider mites	 Root-knot nematodes	 Spotted stem-borer	 Storage pests	 Thrips
 Weeds	 Couch grass	 Turnip Mosaic Virus (TuMV)	 Tomato Yellow Leaf Curl Virus Disease (TYLCV)	
 African Cassava Mosaic Virus	 Anthrax	 Bacterial wilt	 Black rot	 Damping-off diseases
 Downy mildew	 Early blight	 Fusarium wilt	 Late blight	 Powdery mildew

3. Use agro chemicals and its effects

Pesticides are substances that destroy various agricultural pests, including weeds (herbicides), insects (insecticides), bacteria (micro biocides), and fungi (fungicides). Industrial crop production relies heavily upon pesticides, in part because the practice of monocropping increases vulnerability to pests. Unfortunately, pesticides can cause health problems in farm workers who apply the chemicals and who harvest the crops, and in consumers who eat foods with pesticide residues. Various pesticides have been linked to certain types of cancer, to neurological problems, and to other health problems. Pesticides also cause environmental damage such as water pollution and

soil contamination. The use of pesticides can also make pest control more difficult; as in the case of insect control, insecticide use can have the unintended consequence of eliminating insect predators that prey upon pest insects, and can also increase pesticide-resistance in pest insects.

In addition, pesticides have been shown to cause declines in pollinators and other beneficial insects that are critical to the health of agricultural systems.

Sustainable crop production greatly reduces pesticide use; in fact, many sustainable farmers do not use commercial pesticides at all.

4. Integrated Pest Management (IPM).

A number of alternatives to commercial pesticides can be used to protect crops from damage by pests such as weeds and insects, including Integrated Pest Management:

Integrated pest management, or IPM, is a pest-management system that integrates several pest-management approaches. Principles of IPM include monitoring and identifying pests before they become a threat; intercropping and crop rotation to reduce buildup of pests; preventing pests before they reach damaging levels; use of plants that are natural insect repellants; and managing pests using a tiered system of control, including manual removal (e.g., weeding or trapping). Pesticides are generally used sparingly and only when other methods fail.

Intercropping is a method of planting crops in close proximity in order to reduce weeds, to encourage plant diversity in order to avoid insect and pest infestation, and for other agricultural reasons.

Companion planting is a related method that capitalizes on plants that are natural pest repellants (for example, marigolds), plants that are more attractive to pests than the primary crop, or plants that attract beneficial insects.

Mulching, groundcover, and manual control: Mulching is the process of spreading organic or mineral (rock) material to manually control the growth of weeds. Groundcovers (also known as “living mulch”) are generally plants that are grown close to the ground below the main crop in order to control weeds. Weeds and insects may also be prevented by manual removal, though this is a highly labor-intensive process.

Release of beneficial insects and organisms: There are a number of beneficial insects and organisms that, when released, destroy harmful pests. Beneficial insects include predators such as ladybugs; Parasitic wasps, beneficial organisms

include nematodes (microscopic worms) that are used to destroy the larvae of pests.

Ecological plant pest, plant disease and weed management is based on:

- Enhancement of a healthy, fertile soil and good growing conditions to promote healthy plants.
- Growing suitable varieties that are adapted to the local conditions and resistant to major pests and diseases.
- Proper monitoring of pests and diseases in order to encourage timely and effective intervention.
- Non-reliance on externally sourced and costly inputs.
- Minimizing the spread and multiplication of pests, diseases and weeds and thus reducing losses in the field and during storage.
- Enhancement of natural predators to encourage natural control mechanisms.
- Direct control tools that respect and protect the natural resources soil, water, air, and biodiversity. Negative impact on the environment is also avoided by not using synthetic fertilisers and pesticides.

Healthy plants are also able to resist and tolerate physiological disruption and damage from disease-causing organisms and pests. Thus, ecological friendly farmers aim at optimizing the growing conditions for their crops to make them strong and competitive. At the same time they encourage natural control mechanisms to prevent pests, diseases and weeds to develop in a way that they cannot damage the crops. They, therefore, give priority to preventive measures to prevent and limit the spread of infections, instead of relying on direct control measures.

Direct control measures are mainly applied when pathogens have already developed

In order to develop ecological techniques of pest management, the following checklist is followed:

- i. Preventive Measures- crop production practices are analyzed to find out whether they

can be changed to prevent a build up of pest population.

- ii. Control Measures: They are considered starting with weaker ones and ending with the strong ones.

Some pests and diseases control measures are:-

- Start with disease free seeds, cuttings or propagation materials
- Grow disease resistant materials i.e. indigenous crops
- Quarantine incoming plant materials
- Monitor and suppress insects and mites population as soon as noticed
- Keep the environment clean use good spacing
- Avoid plant stress i.e. water, soil pH, nutrients and environment especially in greenhouse
- Keep unauthorized personnel to a minimum
- Use organic pesticides and natural remedies as the last resort
- Ensure permanent soil fertility by deep digging, mulching, composting
- Use recommended ways of cultivation to keep away predators i.e. sheltering with trees, use of attractants, crop diversity, crop rotation, mixed cropping and intercropping

The three-step approach

Integrated pest, disease and weed management can be seen as a three-step approach with multiple tools.

1. Providing good growing conditions for plants to enhance their resilience and resistance.
2. Encouraging natural control mechanisms through promotion of natural enemies.
3. Application of direct control measures to kill the pests, diseases or weeds in a way that has minimum residual effect to the ecosystem.

Each step of the three-step approach builds the foundation for the next step.

The aim is to optimize steps 1 and 2 in order to encourage natural self-control of pathogens and to minimize the direct control measures (step 3). With proper and efficient application of steps 1 and 2, direct intervention is usually not needed. This saves on costs and prevents negative impacts of some direct control tools on the farm ecosystem

1. Crop management practices

These practices aim at providing good growing conditions to enhance plant health and prevention of introduction and spread of pests and diseases. This can be achieved through the following practices:

- Choice of appropriate crop varieties suitable for the location. Where possible, varieties tolerant or resistant to pests and diseases should be used.
- Using clean planting materials.
- Soil fertility improvement to encourage strong and vigorous growing plants, by using compost, animal manure, green manure and other organic materials.
- Intercropping and crop rotation to reduce the multiplication rate of pests.
- Other good management practices to ensure proper growth (e.g. timely planting, proper spacing, water conservation, pruning, shade management and timely harvesting).

2. Habitat management practices

These practices aim at enhancing the proliferation of a variety of organisms (including natural enemies) around and within the crop fields. These include:

- Planting hedges of indigenous plant species around fields to attract natural enemies.
- Allowing flowering plant species to grow within crops to provide nectar and pollen for natural enemies like ladybird beetles, hoverflies and parasitoids.
- Trap cropping to attract pests to non-crops or push away pests from the crops (e.g. push-pull strategy).
- Field hygiene, including timely weeding to remove alternative hosts, roguing infected

plants and plant parts, proper disposal of infected plants and disinfecting tools used on infected plants/fields.

3. Direct control measures

In situations of heavy infestations or very devastating pests and diseases, direct measures will be needed to minimize losses. These include:

- Biological control agents such as predatory insects and mites, insect parasitoids, viruses and bacteria.
- Approved or self-made insecticides or acaricides (against mites) of biological or mineral origin including plant extracts, plant oils, mineral oil, copper and sulphur.
- If available, insect pheromone traps may be used to disrupt mating of pests. Light, bait or colour traps may be used for mass-trapping pests.
- Hot water treatments of seeds to limit seed-borne diseases

Monitoring of pests, diseases and weeds

Regular monitoring of pests, diseases and weeds is the basis for effective management. To be able to manage pests, diseases and weeds, information is needed on the specific pests, diseases and weeds present in the region, village or crop fields and the associated damage they cause.

Typical signs of pest attacks on crop plants

Most crop pests belong to the insects, mites and nematodes. However, in Africa, mammals (like elephants, monkeys or voles), and birds (like sparrows, starlings and crows) can also damage crops.

Insect damage can be categorized by:

- biting and chewing (e.g. caterpillars, weevils),
- piercing and sucking (e.g. aphids, psyllids)
- boring (e.g. borer, leaf miner) species.

Some insect pests are slow moving (e.g. caterpillars), fast moving (e.g. fruit flies), hidden

(e.g. stem borer), or easy to observe (e.g. caterpillars, weevils).

Pest damage is often species-specific:

- leaves with holes or missing parts is an indication of caterpillar or weevil damage;
- curled leaves is an indication of aphids;
- damaged or rotten fruits are often caused by larvae of fruit flies;
- withering plants can also be caused by larvae of noctuids or the stem borer;
- branches or trunks with holes may be an attack by lignivorous insects.

Some mites are very small and barely seen with the naked eye. However, some mite species (spider mites) form a web on the attacked plant parts and can, therefore, easily be detected. If mites are present on plants, leaves and fruits become yellowish.

Banana Weevils – lays eggs in pseudo stem. The larvae bore holes in the ground if you can cut attacked base, you see holes with grass

Green Scales – Leaves become black with sticky substance on young trees

White fly – Tiny flies white in colour, cluster on underside of leaf and when disturbed they fly out in a white cloud

Nematodes are also very small and therefore, they are not easy to observe with the naked eye. They mostly attack plant roots; plants become yellow, wither and die.

Typical signs of disease attacks on crop plants-

Most crop diseases are caused by fungi, bacteria or viruses.

- Fungi cause the great majority, estimated at two-thirds, of infectious plant diseases. They include all rusts, smuts, leaf curls, mildew, sooty moulds and anthracnose. In addition, they are responsible for most leaf, fruit, and flower spots, cankers, blights, wilts, scabs, and root, stem, fruit, wood rots among many

others. Parts of plants or the total crop plant can wither and die.

- Bacteria cause any of the four following main problems.
 - Some bacteria produce enzymes that breakdown the cell walls of plants anywhere in the plant. This causes parts of the plant to start rotting (known as ‘rot’).
 - Some bacteria produce toxins that are generally damaging to plant tissues, usually causing early death of the plant.
 - Others produce large amounts of very sticky sugars; as they travel through the plant, they block the narrow channels preventing water getting from the plant roots up to the shoots and leaves, again causing rapid death of the plant.
 - Finally, other bacteria produce proteins that mimic plant hormones. These lead to overgrowth of plant tissue and form tumours.
- Viruses mostly cause systemic diseases. Generally, leaves show chlorosis or change in colour of leaves and other green parts. Light green or yellow patches of various shades, shapes and sizes appear in affected leaves. These patches may form characteristic mosaic patterns, resulting in general reduction in growth and vigour of the plant. Before managing any particular pests, diseases and weeds, the farmer should know how it behaves in relation to the concerned crop.

Examples of diseases

- a) Bacterial Wilt -Also known as Stewarts disease
Symptoms – the infected plants wilt and die rapidly. Starting with young leaves even when the weather is wet (b) lower foliage may turn yellow slightly (c) a length wise stem cut reveals an oozy grey-brown core.
- b) Powdery Mildew-Attacks mainly in wet weather, white powdery deposits occur on flowers and leaves

Guiding criteria for understanding pests, diseases and weeds

Pests
• At what stage of the lifecycle is it a pest: larvae, caterpillar or adult?
• At what stage of plant growth does it attack: seedling, growing or mature plant?
• Which part of the plant does it attack: leaves, roots, stem, fruits, seeds or the entire plant?
• What kind of damage does it cause: chewing, sucking or the death of the plant?
• When does it attack: dry season or wet season?
Diseases
• What is the cause of the disease: virus, bacteria or fungus?
• How is the disease transmitted: by seeds, through the soil, by air or by insects?
• At what stage of plant growth does it attack: seedling, growing or mature plant?
• Which plant part is attacked: leaves, roots, stem, fruits, seeds or the entire plant?
• What kind of damage does it cause: rotting, chlorosis, wilting, spots, etc.?
• When does it attack: in the dry season or the wet season
Weeds
• Is the weed perennial or annual?
• How is it spread: by seeds, rhizomes, etc.?
• Which conditions promote its growth?

Field scouting for pests and diseases

Careful and continuous monitoring of pest and disease levels during critical times of growth of a crop is the key to successful management.

This can be done through regular scouting of the field by the farmer. It helps the farmer to intervene early enough before the pest and/or disease cause significant damage.

Scouting avoids unnecessary use of natural plant extracts. Limited use of these substances (e.g. pyrethrum, neem) and oils is important as they also have negative effects on beneficial insects. If the application of these substances is not regulated, many pest predators and parasitoids may be killed as well. Over application of these substances may also lead to pests developing resistance.

Therefore, scouting should be planned and done in an organized way. It is important to get a random sample that will be representative of the overall

situation in the crop garden. Therefore, the scout (farmer) needs to observe and record any of the findings for better decision making. The most common pattern in pest and disease scouting programs involves walking along a predetermined zigzag or M-shaped route through a field. This pattern is commonly used because it is easy to teach, convenient to use, and ensures that all regions of the field are visited.

To monitor insect pests, different traps can also be used. The simple idea is to know more about the presence of the insect pests in the field especially the fast moving (mobile) insect pests (e.g. fruit flies, lepidopteran pests).

- Fruit flies can be captured using bait traps. For example, PE-bottles with small holes can be half-filled with water, some cattle urine, fruit flesh or a small dead fish and a drop of detergent or soapy water. These bottles are then hung in trees and checked every three days.
- Yellow plastic cards coated with adhesive are also good for trapping aphids and leafhopper. yellow-orange plastic boards are appropriate for white flies, while blue cards are appropriate for thrips monitoring.
- Light traps are especially needed where noctuids (e.g. moths, cutworms, African armyworm, and cotton bollworm) are a problem. Within crops attacked by cutworms, visual checks of caterpillars have to be done by dawn.

- **Insecticides of plant or mineral origin**

There are commercial organic insecticides available in many countries of Africa (e.g. neem, and pyrethrum). Most of them can be handcrafted by farmer cooperatives or by the individual farmers.

The neem tree (*Azadirachta indica*) originally comes from India, but today it is known all over Kenya. The neem tree has over 100 compounds with pesticidal properties. The highest concentration of the most important compound azadirachtin is in the fruit, especially in the seeds. Neem acts as a broad-spectrum repellent, insect

growth regulator and insect poison. Unlike most botanical insecticides, neem also has a somewhat 'systemic' effect.

This means that plants can take up neem extracts through their roots and leaves, spreading the material throughout the plant tissues. For this reason neem can help control pests such as leaf miners. Neem products are effective against a wide range of pests: about 400 pest species are known to be affected by neem extracts. In spite of its broad spectrum action, neem products generally do not harm natural enemies.

Neem products with high oil content are phytotoxic to some plants, meaning that plants may be burned when neem extract is used at a high dosage. Therefore, the extracts should be tested on a few plants before going into full scale spraying. At the same time, however, neem extracts are rapidly decomposed by sunlight. For this reason, commercial products usually contain a sunscreen that protects the extract from sunlight, allowing for a longer exposure to sunlight.

Recommendation to farmer about preparation of neem pesticides:

- Neem pesticides can be prepared from the leaves or from the seeds. The leaves or seeds are crushed and mixed in water, alcohol or other solvents. For some purposes, the resulting extracts can be used without further refinement.
- Ground neem seeds (neem cake) or neem kernel powder is used as a soil amendment and is effective for control of nematodes. It is also used for control of stalk borers and to prepare water extracts, which are then sprayed onto plants.
- Neem cake has a considerable potential as a fertilizer and at the same time it will hinder nematode attacks of the crop roots (e.g. tomato). Put neem cake in the planting pit (200g per m²) and mix it with substrate. The neem cake will repel and even kill nematodes and other root pests. Insecticidal agents (azadirachtin) will be

translocated to above-ground parts of the plant and help to get rid of pests there.

Pyrethrum is a natural insecticide derived from African *Chrysanthemum cinerariaefolium* flowers. They are perennial plants with a daisy-like appearance and white flowers. The plant is most productive at altitudes above 1600 meters and ideally in semi-arid conditions. On richer soils the insecticidal properties are reduced. The content of the active substances increases with altitude and cooler average temperatures.

Pyrethrum extracts should not be mixed with lime, sulphur, or soap solutions during application since pyrethrum is broken down by both acid and alkaline conditions. In addition, pyrethrum extract is also rapidly broken down by sunlight. Pyrethrum is a broad-spectrum and contact poison for controlling pests on flowers, fruits and vegetables. It can be used to control most aphids, spider mites, thrips, whiteflies, African armyworm, African bollworm, cutworms, maize stalk borers and potato jassids.

Recommendations to farmers on preparation of pyrethrum pesticides:

- Pyrethrum powder is made with dried ground flowers. Use pure or mix with a carrier such as talc, lime or diatomaceous earth and sprinkle over infested plants. To make liquid pyrethrum extract (mix 20g pyrethrum powder with 10 l water), add soap to make the substance more effective. Strain and apply immediately as a spray. For best effects this should be applied in the evening. Pyrethrum can also be extracted by alcohol.

Chillies and capsicum pepper have both repellent and insecticidal effects.

Recommendations to farmers on preparation of chilli pesticides:

To make the chilli extract: grind 200 grams of chillies into a fine dust, boil it in 4 litres water, add another 4 litres of water and a few drops of liquid soap. This mixture can be sprayed against aphids, ants, small caterpillars and snails.

Garlic has antifeedant (insect stop feeding), insecticidal, nematicidal and repellent properties. Garlic is reportedly effective against a wide range of insects at different stages in their life cycle (egg, larvae, adult). This includes ants, aphids, armyworms, diamondback moth, whitefly, wireworm and termites. Garlic is non-selective, has a broad-spectrum effect and can kill beneficial insects as well. Therefore, it should be used with caution.

Recommendations to farmers on preparation of garlic pesticides:

To make the garlic extract, grind or chop 100 grams garlic into 0.5 litre water. Allow mixture to stand for 24 hours, add 0.5 litre of water and stir in liquid soap. Dilute at 1:20 with water and spray in the evening. To improve efficacy, chilli extract can be added.

There are many other extracts of plants known to have insecticidal effects like tobacco (*Nicotiana tabacum*), yellow root (*Xanthorrhiza simplicissima*), fish bean (*Tephrosia vogelii*), violet tree (*Securidaca longepedunculata*), and nasturtium (*Nasturtium trapaeolum*) which are traditionally used to control pests in Kenya.

Precautions to farmers regarding use of plant extracts:

- Do not have direct skin contact with the crude extract during the process of preparation and application. Plant extracts like tobacco can also be very toxic to humans. Contact with plant extracts should be avoided in the eyes.
- Make sure that you place the plant extract out of reach of children during Storage
- Wear protective clothing (eyes, mouth, nose and skin) while applying the extract.
- Wash your hands after handling the plant extract.

Sulphur is probably the oldest known pesticide in use. In ecological agriculture it is mostly used against plant diseases, but is also used against mites (acaricide). The acaricidal effect of sulphur is best at temperatures above 12° C.

However, sulphur has the potential to cause plant injury in dry hot weather (above 32° C). It's also incompatible with other pesticides.

Sulphur should not be used together or after treatments with oil to avoid phytotoxicity.

Wood ashes from fire places can be efficient against ants, leaf miners, stem borers, termites and potato moths. Ash should be dusted directly on pest colonies and infested plant parts. The ash will dehydrate the soft bodied pests. Wood ashes are often used when storing grains to deter storage pests such as weevils.

- **Pheromones for mating disruption**

Pheromone dispensers release a sex hormone from the female insect. Few dispensers combined with special traps attract the male insects into the trap in which they get stuck.

Pheromone traps are mostly used for monitoring pest insects but can also be used for mass-trapping. Several types of pheromone traps have been developed for monitoring African bollworms, cutworms, fruit flies, etc. and are widely used. However, in most parts of Kenya, pheromone traps are not locally available and imported ones are not affordable to small-holder farmers.

Sex pheromones can also be used for mating disruption. Here, a high number of dispensers are installed in the crop (apple orchard, vineyard) to get a pheromone cloud within or over the crop. Male insects will then not be able to find the female and mating is, therefore, disrupted. Consequently no offspring will damage the crop.

- **Repellents against mammal pests**

Not only insect, mite, nematode and slug species are known as pests, mammals such as elephants, monkeys, wild pigs, etc., destroy subsistence crops and threaten the livelihood of rural farmers across Kenya. However, there are effective, nonlethal repellents known to drastically reduce the damage caused by elephants.

The basic repellent agent is derived from Capsicumchillies or hot peppers (Pili pili kali).

If crops are protected with elephant fences (at least 2.5 meters or 8 feet high with two parallel lines), squares of cloth or burlap soaked in a petroleumbased agent (motor oil) mixed with chilli powder can be fixed between lines. The very strong odour of capsicum peppers causes adverse physical reactions from elephants, including irritation of the eyes and burning sensations in the trunk.

An additional approach is to produce chilli dung bombs with crushed chilli and animal dung. To give the mixture of chilli and dung a solid shape, the farmer may use a brick mould. The elephant bombs should dry for a day or two and then be placed in equal dispersal around the field. The farmer may set fire to them at nightfall. Elephant bombs will create a spicy smoke that keeps elephants out of farmers' fields of maize, sorghum and millet. The same agent can be prepared against wild pigs, monkeys and other mammals.

chillies, chives, garlic, coriander, nasturtium, spearmint and marigold are plants known to have a repellent effect on different pest insects (aphids, moths, root flies, etc.) and can be grown as intercrop or at the border of crop fields. Marigold is especially known to deter root nematodes, while neem cake is known to deter mice.

- **Traps for mass-trapping of pests**

Mass-trapping of pests is an additional control measure. They often can easily be built with cheap material.

Light traps can be used to catch moths such as armyworms, cutworms, stem borers and other night flying insects. Light traps are more efficient when placed soon after the adult moths start to emerge but before they start laying eggs. However, light traps have the disadvantage of attracting a wide range of insect species. Most of the attracted insects are not pests. In addition,

many insects that are attracted to the area around the light traps (sometimes from considerable distances) do not actually fly into the trap.

Instead, they remain nearby, actually increasing the total number of insects in the immediate area.

Colour and water traps can be used to monitor adult thrips. In some cases thrips can even be reduced by mass trapping with coloured (blue, yellow or white) sticky traps or water traps in the nursery or field. The colour spectrum of the boards is important for the efficacy of the sticky traps. Bright colours attract more thrips than darker ones. Sticky traps with cylindrical surfaces are more efficient than flat surfaces. They are best placed within a meter of crop level. Traps should not be placed near the borders of fields or near shelter belts.

Water traps should be at least 6 cm deep with a surface area of 250 to 500 cm², and preferably round, with the water level about 2 cm below the rim. A few drops of detergent added to the water ensure that thrips sink and do not drift to the edges and escape. Replace or add water regularly.

Yellow sticky traps can be used to control whiteflies, aphids and leaf mining flies. Yellow plastic gallon containers mounted upside down on sticks coated with transparent car grease or used motor oil, is one such trap. These should be placed in and around the field at about 10 cm above the foliage. Clean and re-oil when traps are covered with flies. Yellow sticky boards have a similar effect. To use, place 2 to 5 yellow sticky cards per 500 m² field area. Replace traps at least once a week.

To make your own sticky trap, spread petroleum jelly or used motor oil on yellow painted plywood (size 30 cm x 30 cm). Place traps near the plants but faraway enough to prevent the leaves from sticking to the board. Note that the yellow colour attracts many insect species, including beneficial insects, so use yellow traps only when necessary.

Traps for house flies and fruit flies Fruit flies and house or barn flies are attracted to fermenting fruit juice. The top of a plastic bottle can be cut off and inverted. A little sugar water or honey can be smeared around the rim of the bottle to further attract the flies, which will then enter the bottle containing sweet/ fermenting fruit juice and be trapped. Fruit fly traps can be made locally using an ordinary jar with plastic containers or plastic bottles, in which holes have been cut. They can be used with food baits such as protein hydrolysates, yeast or sweet/fermenting fruit juice.

- **Physical barriers against pests**

There are different physical barriers known to have a control effect on pests (like insect fences and fruit bagging). However, the most useful measure is fruit bagging. Fruit bagging prevents fruit flies from laying eggs on the fruits. In addition, the bag provides physical protection from mechanical injuries (scars and scratches). Although laborious, it is cheap, safe and gives a more reliable estimate of the projected harvest. Bagging works well with melon, bitter gourd, mango, guava, star fruit, avocados and banana (plastic bags used).

Recommendations to farmers regarding fruit bagging:

Cut old newspapers to fruit size and double the layers, as single layers break apart easily. Fold and sew or staple the sides and bottom of the sheets to make a rectangular bag. Blow in the bag to inflate it. Insert one fruit per bag then close the bag and firmly tie the top end of the bag with sisal string, wire and banana fibre or coconut midrib. Push the bottom of the bag upwards to prevent fruit from touching the bag. For example, start bagging the mango fruit 55 to 60 days from flower bloom or when the fruits are about the size of a chicken egg. When using plastic bags (e.g. with bananas), open the bottom or cut a few small holes to allow moisture to dry up. Moisture trapped in the plastic bags damages and/or promotes fungal and bacterial growth that causes diseased fruits. Plastic also overheats the fruit. Bags made of dried plant leaves are good alternatives to plastic.

Direct control measures in disease management

Direct control measures against diseases include biological control (using other living organisms like parasitic fungi to control diseases) and the application of fungicides of biological or mineral origin. All measures are used as a last option for the control of pests, when all methods used in the preceding steps have failed. For organic production, only agents of non-synthetic origin are permitted. Even the often criticized agents copper and sulphur are of mineral origin so their use is also restricted.

Farmers should be encouraged to find out more about the efficacy of the different materials by conducting their own farm experiments. They should set up their own plots as a group or individual farmers to be able to compare the effects between treated and untreated plants. Be aware that some materials have preventive effects while others (like copper) have therapeutic effects. Therefore, the agents with preventive effects must be applied before disease attacks.

Biological control of plant diseases

Fungi belonging to the genus *Trichoderma* are worldwide in occurrence and easily isolated from soil, decaying wood and other forms of plant organic matter. On the one hand, *Trichoderma* species are known to parasitize other fungi and within them some important plant diseases like damping off (*Rhizoctonia solani*). On the other hand, antibiosis and competition are other impacts of *Trichoderma* species on plant diseases like *Sclerotinia*, *Pythium*, and *Botrytis*.

Trichoderma harzianum (different strains) were tested under subtropical and tropical climates. Some good effects are reported against red rot (*Colletotrichum falcatum*), seed and seedling blight of cowpea (*Macrophomina phaseolina*), powdery mildew and other diseases. In addition, *Trichoderma* works as growing stimulant and, therefore, improves yields and product quality (e.g. soybean).

Species of *Aspergillus* are almost ubiquitously present in soils of tropical areas. They are best

known for contamination of seeds with highly poisonous aflatoxins resulting from the presence of toxigenic strains of *A. flavus*, *A. parasiticus*, *A. nomius* and *A. bombycis*. However, there are also non-aflatoxigenic strains of *A. flavus* and *A. parasiticus* that can be used as biocontrol agents against dangerous *Aspergillus* species.

Some bacteria are known to control plant diseases. An often used bacterium is *Bacillus subtilis* (different strains) with effects against fungi diseases like *Botrytis*, powdery mildew or black spot. Other examples are *Pseudomonas fluorescens* (and other *Pseudomonas* species), *Bacillus* and *Azotobacter* species. The principles of action are competition for root niches, competition for nutrition elements, production of secondary metabolites and antibiosis. However, the use of these bacteria as biocontrol agents strongly depends on the availability of cheap products.

- **Fungicides of Plant or mineral origin**

There are commercial organic fungicides available in many countries of Africa including products with the fungicidal agents copper, sulphur and acidic clay.

Bordeaux mixture (Copper sulphate and lime) has been successfully used for over 150 years, on fruits, vegetables and ornamentals. Unlike sulphur, Bordeaux mixture is both fungicidal and bactericidal. As such, it can be effectively used against diseases such as leaf spots caused by bacteria or fungi, powdery mildew, downy mildew and various anthracnose pathogens. The ability of Bordeaux mixture to persist through rains and to adhere to plants is one reason it has been so effective. Bordeaux mixture contains copper sulphate, which is acidic, and neutralized by lime (calcium hydroxide), which is alkaline.

Recommendations to farmers on preparation of Bordeaux mixture:

Bordeaux mixture comes in several formulations. One of the most popular, effective and least phytotoxic formulations for general use is the following formulation: Mix 90 grams of blue

copper sulphate with 4.5 litres of water (in a nonmetallic container). In another non-metallic container, mix 125 grams of slaked lime with 4.5 litres of water. Stir both, mix both solutions, and stir again. This formulation was developed in recognition of the fact that copper, like sulphur, is phytotoxic and that the level of toxicity is related to the age of plant tissue being treated. Application of Bordeaux during hot weather (above 85° F or 30° C) may cause yellowing and leaf drop. Additionally, leaf burn can occur if it rains soon after a Bordeaux application. Care should be taken when applying this fungicide to young, tender leaves of fruit trees. Do not apply Bordeaux mixture to corn or sorghum, which are described as copper-sensitive plants.

Sulphur is mostly used against plant diseases like powdery mildew, downy mildew and other diseases. The key to its efficacy is that it prevents spore germination. For this reason, it must be applied prior to disease development for effective results. Sulphur can be applied as a dust or in liquid form. It is not compatible with other pesticides.

Lime-sulphur is formed when lime is added to sulphur to help it penetrate plant tissue. It is more effective than elemental sulphur at lower concentrations. However, the odour of rotten eggs usually discourages its use over extensive fields.

Acidic clays have a fungicidal effect due to aluminium oxide or aluminium sulphate as active agents. They are used as an alternative to copper products but, are often less efficient. Different products are available on the market in a few African countries.

Milk has also been used against blights, mildew, mosaic viruses and other fungal and viral diseases. Spraying every 10 days with a mixture of 1 litre of milk to 10 to 15 litres of water is effective.

Mildew and rust diseases on plants can be controlled with a mixture of baking or washing soda. Spray with a mixture of 100 grams of

baking or washing soda with 50 grams of soft soap. Dilute with 2 litres of water. Spray only once and leave as long gaps as possible (several months). Do not use during hot weather and test the mixture on a few leaves because of possible phyto-toxic effects.

Many plant extracts are known to have fungicidal effects. Onion and garlic are effective against many diseases such as mildew and fungal and bacterial diseases.

Mexican and African marigold act as a crop strengthener to help potatoes, beans, tomatoes and peas resist fungal diseases such as mildew.

The leaves of pawpaw (*Carica papaya*) and sweet basil have a general fungicidal effect.

Many other plant species in Africa are known to have fungicidal effects. Traditional knowledge might be of help to amend the range of plant extracts in each region of Africa.

- **Hot water treatments for seeds**

Hot water treatment of own seed to prevent seed-borne diseases such as black rot, black leg, black spot and ring spot of crucifers is very effective. It reduces the seed-borne pathogens such as *Alternaria* spp., *Colletotrichum* spp., *Phoma* spp., *Septoria* spp. and bacterial pathogens (*Pseudomonas* spp. and *Xanthomonas* spp). However, hot water treatments are delicate as seeds can rapidly be destroyed by too hot temperatures.

Therefore, specified temperature and time intervals must be strictly followed in order to maintain seed viability. Use a good thermometer or ask for assistance from an experienced person or from your local extension officer. To make sure that the seed is not damaged it is advisable to test the germination of 100 heat treated and 100 untreated seeds. Hot water treatment can also be used for potato tubers (10 minutes in water at 55° C) to control blackleg infection, powdery scab and black scurf, and banana suckers to control nematodes and banana weevils.

4. Weeds and weed management.

A weed is a plant growing in a place where it is not wanted by humans. In agriculture, weeds may damage crops when growing in fields or poison domesticated animals when growing on pasture land. They can roughly be grouped into annual and perennial plant species.

- Annual weeds are plants that normally take advantage of temporarily bare soil to produce another generation of seeds before the soil is covered again by crops.
- Perennial weeds are plants that grow for many seasons. They propagate either by seeds or by the spread of vegetative parts, such as roots or tubers. Re-generation by vegetative means is a unique characteristic to perennial weeds, meaning even the smallest root or stem can reproduce an entire plant.

Steps in weed management:

a) Crop management practices

These practices aim at limiting the introduction and multiplication of weeds.

These include:

- Use of crop seeds free of weed seeds.
- Appropriate land preparation, adapted to either annual or perennial weeds.

Perennial weeds should be removed as much as possible before planting or covered with an aggressive green manure plant, otherwise they are difficult to control after planting the main crop.

b) habitat management

These practices aim at reducing the impact of weeds on the growing plants:

- Intercropping or cover cropping to rapidly cover the soil before weeds emerge.
- Mulching to suppress weed growth.

c) Direct control

On top of the practices in the 2nd step, direct control practices may be applied to completely eliminate the weeds. These practices include:

- Mechanical control by hand, animal traction or appropriate machines to remove weeds.
- Use of biological control agents, meaning the use of specific plant diseases or plant pests against weeds.
- Thermal weed control (flame weeding).

b. Safe use of chemicals

It is important to follow label instructions for the mixing, loading and handling of the specific pesticide being used and the actual conditions of use

- Do not spray pesticide during high winds, high sun and when it is raining.
- The amount of pesticide concentrate needed to treat a specific site should be carefully calculated.
- The water used to prepare pesticides should be free of pathogenic organisms.
- Special attention should be paid to spray equipment, pumps and nozzles used to apply pesticides.
- To minimize the potential for over or under treatment, accidents and spills, equipment should be calibrated for accuracy and checked frequently for malfunctions.
- Spray equipment should be regularly washed to prevent possible contamination of fruits or vegetables with compounds not authorized for that commodity and to avoid accidentally overdosing.

Warning signs

These should be posted on fields that have recently been treated with pesticides to prevent workers or visitors from inadvertently coming in contact with treatment chemicals. Such signs should only be removed after the established re-entry period into the field has passed so that residual levels are at an acceptable level.

Personal protection equipment during mixing, filling and cleaning/maintaining the sprayer

Thorough training of personnel responsible for using and applying pesticides is critical. They should be aware of the dangers that can result from improper use of the product. They also should be trained in the use of safety equipment and application devices such as:

- gloves or plastic bags on hands;
- eye protection – i.e. visor, goggles, to protect eyes;
- cotton clothes to cover the body, long trouser legs worn outside the boots, long sleeves; boots or shoes that cover the feet (NEVER • sandals); a hat;
- a light disposable mask or respirator;
- waterproof apron or large plastic bag to cover the front of the body
- always have soap and water available to clean spilled pesticide off the skin.
- Field workers should be reminded that adverse health effects caused by pesticides are often not noticeable in the short term, but can develop over time if exposure is not reduced.

Remember to keep children, pregnant women and animals at a safe distance during the spraying.

Cleaning and maintaining the sprayers

After spraying, the sprayers should be washed with soap or detergent at the special designated area to avoid contamination. Care should be taken not to remove the protective clothes or gloves until you are through with the washing. Washing and the remains from spraying should be poured in a special designed soak pit; the soak pit may be filled with charcoal or small stones to avoid contamination of water, soil and animals

(NEVER pour washing in the rivers/streams or irrigation canals). Cleaned sprayers should be kept in the safety store and personnel involved in the spraying must take a shower immediately. Protective equipment should be inspected

periodically and kept clean and in good condition. After use, all equipment should be carefully washed in soapy water and rinsed with clean water.

Time before entering the spray field (withholding period)

Some crop protection products require a wait between spraying and authorized return to the field. This first allows residues to fall to an acceptable level and prevents the risk of contamination of persons working in or crossing the field. When such risks exist, the minimum waiting period before returning to the field is specified on the label. These instructions must be followed scrupulously and, even when no period is mentioned, waiting for 24 hours after the last application is an elementary precaution. These periods for humans also apply to animals.

Pre-harvest intervals – (PHI)

The label must specify, according to the product, the waiting period between the last spray and harvesting date. This period must be strictly observed so that the residue level does not exceed the acceptable limits.

Storage of pesticides in rural areas (on smallholdings)

Provide an unused empty cabin or a drum with door cut for pesticide storage.

- Keep pesticides under lock and key in a cupboard or box inside the empty cabin.
- Hide the keys, to the cupboard or box and cabin where the pesticides are stored in a safe place.
- Never store pesticides in the kitchen.
- Never store pesticides in bedrooms or in occupied rooms.
- Never leave pesticides within the reach of children
- Put up clearly visible signs forbidding entry to the cabin where pesticides are stored.
- Always keep pesticides in their original containers.

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- Avoid storing pesticide for a long time, because they may become obsolete.
- Never decant pesticides into beverage or oil bottles.
- Keep pesticides away from fire and out of direct sunlight, rain.
- A warning sign with a skull and crossbones should be kept in place
- Remember to keep a container of clean water (eye wash) outside the pesticide store, to clear any pesticide splashes.

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CHAPTER 12: AGRO- FORESTRY

1. Introduction to agro forestry

Agroforestry is intensive land use management combining trees and/or shrubs with crops and/or livestock. It involves the deliberate retention, introduction, re-introduction or management of trees or shrubs in agricultural systems where ecological, economic or social benefits result from interaction between agriculture and /or livestock and tree husbandry

Agroforestry practices help farmers to diversify products, markets, and farm income; improve soil and water quality; and reduce erosion, non-point source pollution and damage due to flooding. The integrated practices of agroforestry enhance land and aquatic habitats for fish and wildlife and improve biodiversity while sustaining land resources for generations to come. In a changing climate, agroforestry practices can be designed and strategically located to provide greater resiliency in agricultural landscapes so farmers can meet production objectives when faced with extreme weather (e.g., drought, floods).

Agroforestry aims to use agro-biodiversity in generating multiple services. Trees and shrubs provide mulching material, green manure, animal fodder, soil erosion control, shade, nutrient cycling and improved soil fertility and also socioeconomic benefits e.g. saleable products such as fruits, fuel wood and charcoal, timber for construction, craft materials, etc.

Trees may be grow with crops or pasture at the same time and in the same filed or at the same time in adjoining fields or in the same filed at different times,. Agro forestry is common on

many farms and involved using shrubs and trees in a variety of ways such as

- In cropland either scattered or planted in lines
- Along boundaries, paths, roads or as live fences
- Along soil conservation structures
- For wind breaks
- Around the homestead for shade or beauty
- In fruit orchards and home gardens
- For improved woodlots for poles and fuel wood
- In cropland or pasture land for fodder or browse
- For gully reclamation and stream bank stabilization

2. Characteristics of trees for agro forestry development

Desirable characteristics of an agroforestry tree species.

- Marketable. This includes both the wood itself and other products such as nuts or fruit, which would provide another source of income.
- Compatible with the companion crops or forage you choose. Some trees produce growth-inhibiting chemicals which may effect what you can grow.
- High quality.
- Fast growing or of such a high value that a species of medium growth rate is acceptable.
- Deep-rooted so the trees do not compete with the crops or forage for moisture.
- Have rapidly decomposing foliage.
- Be properly matched to the site. Site tolerant, suited to either a wet or dry site.
- The leaves should produce a light, rather than a heavy shade. This will be especially

important as the trees mature and the canopy closes. The lighter the shade that is produced, the longer you can grow crops or forages.

- Capable of producing the products you desire.

Ecological Aspects of Agroforestry systems- Agroforestry systems have the following basic principles:

a) Competition between the plants must be minimised.

This can be achieved by planting the plants in such a way that they are not using resources all at the same time. For instance, acacia trees (*Faidherbia albida*) lose their leaves during the millet growing season, and are suitable to feed cattle, as their pods are rich of proteins. Therefore, many African farmers grow acacia trees combining with millet and cattle.

b) Complementarity among the plants must be maximised.

Complementarity and competition depend on the root system of the crops and trees/shrubs, i.e. on the depth or shallowness of the roots. If one has deep, the other one shallow roots, they will not compete for nutrients and water, but might complement/ benefit from each other. (Sanchez 1995)

Agroforestry has following advantages:

- **Improvement of soil fertility.** Trees provide mulch when their leaves, fruits and branches fall down and decompose. This results in an increase of organic matter and recycling of nutrients from deep in the soil, and leguminous trees fix nitrogen that can benefit food crops.
- **Effects on soil moisture and microclimate.** Shading and windbreak effects of trees influence microclimate and help to conserve soil moisture. Shade helps reducing the soil temperature and the amount of water that evaporates into the air. Though their roots may also deprive crops of moisture.
- **Soil conservation.** Trees can conserve the soil in many ways. They cushion the impact of raindrops on the soil and reduce the amount of rain-splash erosion. Their roots bind/stabilise the soil. Planted along contours, they can interrupt the

flow of water running off the surface. They can act as windbreaks protecting the soil against wind erosion

- **Improvement of biodiversity.** Agroforestry systems improve diversity and quantity of animals/wildlife by offering a greater variety of habitats

3. Types of agro forestry trees

Following species were found to perform well, in terms of survival, growth, and wood and foliage production, across diverse agro-ecological zones:

- *Moringa oleifera*
- *Sesbania sesban*
- *Senna siamea*
- *Senna spectabilis*
- *Acacia auriculiformis*
- *Leucaena leucocephala* (except in acidic soils)
- Casuarina
- Calliandra
- *Gliricidia sepium*

4. Role of agro forestry trees

- Nitrogen fixation.

Micro-organisms (bacteria and fungi) in root nodules and mycorrhiza of certain trees and shrubs fix nitrogen from the atmosphere into a form crops can use in the soil. Some examples of nitrogen fixing trees are *casuarina iquisetifolia*, *leucaena leucocephala* e.t.c

- Substitution of nitrogenous fertilizer by leguminous trees.

In humid and sub humid areas nitrogen fixing trees have the capacity to yield 100 –200 kgs N/ha /yr. in dry areas nitrogen yield ranges from 50 – 100 kgs (Kimaru et al., 2000).

- Humus from root and litter decomposition.

Old roots decompose and add organic matter to the soil, leaf litter from trees provides nutrients

and organic matter to the soil. In a process called nutrient pumping or nutrient cycling, roots of trees carry valuable minerals from below the soil surface.

- Improving soil chemical condition.

Trees have the potential to improve acidic soils or soil already rich in bases through addition of bases in tree litter. Organic compounds combine with unbound aluminium ions leading to a lowering in soil acidity.

- Water conservation.

Trees increase soil water retention through organic matter which acts like a sponge thus increasing the soils ability to adsorb and retain water.

- Wind breaks.

Trees act as windbreaks reducing the rates of evaporation caused by high temperature and dry winds and hence helping improve crop performance.

- Shade.

Trees crowns shade the soil thus lowering surface temperature and reducing evaporation losses.

- Conserving soil.

Trees help to control soil erosion in a number of ways I.e. roots hold soil together, trees and shrubs arranged as hedges along contours act as physical barriers that intercept runoff and cause soil to be deposited.

5. Agro forestry systems/methods

The classification of the different types of agroforestry is based on the type of environment and on the combination of the components. Basically, there are three categories of agroforestry systems:

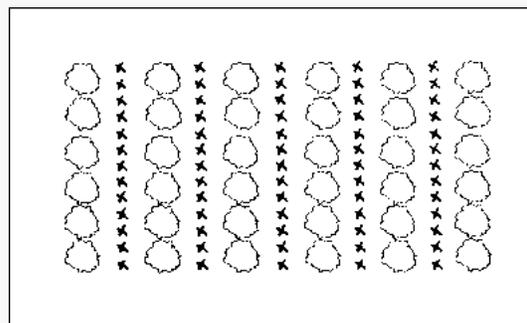
- Agrosilvicultural systems: Trees with crops e.g. taungya and alley cropping
- Silvopastoral systems: Trees with livestock/pasture e.g. trees and shrubs on pastures and multipurpose trees, fodder trees and shrubs grown on or around cropland
- Agrosilvopastoral systems: Trees with both crops and livestock e.g. compound farming.

Next to climatic conditions and soil type, success of agroforestry depends on the right choice of

species combination, management practices and the understanding and motivation for using it. An agroforestry system involves two or more plant species and/or animals (including at least one woody perennial), it has more than two outputs and has a cycle of more than one year.

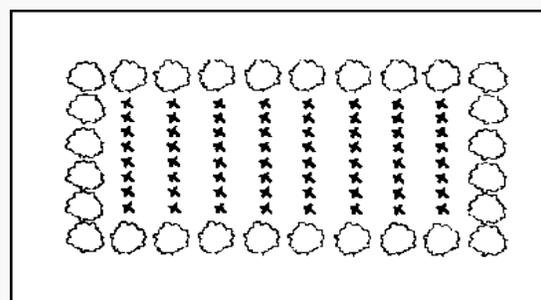
Distribution of the plant components can vary in space and time. Plant components can be mixed in different densities (see images below) and have a separate long/short cropping/fallow cycle.

Patterns/systems



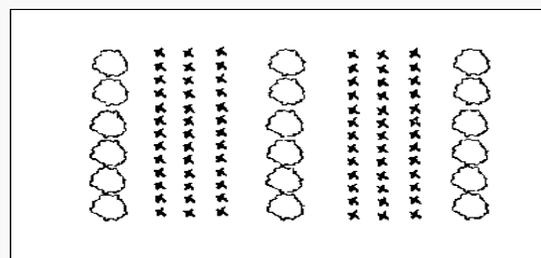
Alternative rows of plant components.

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Trees along borders of fields.

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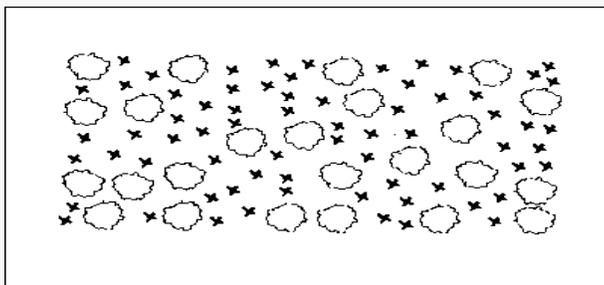
Alternative strips or alley cropping.

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i) Dispersed trees on cropland

The practice of growing trees in fields while crops are grown alongside or underneath can be done either by protecting and managing the trees that are already there or by planting new trees.

There are different spacing patterns and densities of placement depending on the type of tree chosen and of crop grown, but trees are generally planted at least 8-10m apart.



Random mixture of plant components.

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Advantages:

- Growing trees with crops can increase crop yields due to shading and the addition of nutrients and organic matter to the soil.
- Trees can be a breeding place for beneficial insects and other creatures that can reduce crop pest numbers.
- Trees can provide products of commercial and subsistence value.

Disadvantages:

- Trees can attract birds and crop pests, which can damage crops.
- Competition with crops for water, nutrients. It is important to plant trees with deeper roots than those of the crops grown alongside

ii) Compound farming (Home gardens)

Compound farming is also known as home garden, village-forage garden, kitchen garden and household garden. In Africa, they are known as:

Compound farming consists on growing trees, shrubs, vines and herbaceous plants in or around the homesteads, aiming mostly food production for household consumption. In home gardens perennial crops and annual crops are grown side by side. Home gardens are characterised by the intensive use of multi-purpose trees, shrubs, food crops and animals. Typical is also the high species diversity and the complex, layered structure (3-4 vertical canopy layers). Near the ground there is a herbaceous layer consisting of plants such as beans, pulses, root crops grasses and medicinal plants, which grow to about 1.5 metres. The middle layer (1-3 m height) consists of small trees that tolerate some amount of shade such as coffee, tea, banana, papaya or food plants such as cassava, etc. The upper layers are usually about 20 metres high and consist of trees for fruit, fuel, timber, shade and fodder. Animals are also usually included in the system.

Advantages:

- Production of food is continuous and diverse.
- Farmers have easy access to food, timber, fuel, fodder, spices and medicines.
- Home gardens protect the soil and conserve water.
- Labour can be used efficiently because home gardens are situated close to houses.
- Produce may be sold locally and act as a financial buffer in times of need.

Disadvantages:

- The high diversity of plants in a home garden can provide a habitat for species that could become pests or introduce diseases.

iii) Alley cropping

Alley cropping is also known as alley farming or hedgerow intercropping. It consists in growing food crops between hedgerows of shrubs and trees, specially leguminous species. The arrangement of the components is uniform (not mixed), consisting of strips with different widths. During growing of the crops, the hedges get pruned regularly, to avoid shading of the crops

and to provide biomass, enhancing the nutrient status and physical properties of the soil.

Alley cropping is developed to improve or maintain crop yields by improving soil fertility and micro-climate through the cycling of nutrients, mulching and weed control. This can be reached by using specific tree species that produce foliage and fix nitrogen, enriching the soil. By planting deep-rooted trees and shrubs that grow quickly in hedgerows, essential plant nutrients are recycled to the benefit of crops planted in alleys between the hedgerows. Furthermore, a good mixture of trees and shrubs can provide animal fodder, protection against soil erosion, shade and windbreaks, fuel wood and construction material.

Alley cropping is mostly used in humid or sub humid tropical areas on fragile soils and seems to work best where farmers need to intensify crop production but have soil fertility problems.

The technique of alley cropping requires careful planning and management. It is preferable that the species used have a light open crown that lets sunlight pass through onto the crops that are being grown. It is also possible to prune species with a denser crown. The trees used must also be capable of rapid re-sprouting after coppicing.

Alley cropping management cycle

- The trees are planted in lines and crop grown between the rows.
- When the shade from the trees begins to interfere with the crops they are coppiced or pollarded.
- The coppiced branches are placed between the rows. Leaves will fall to the ground adding organic matter to the soil when they breakdown. Branches and twigs can be gathered for fuel or other purposes.
- Trees re-sprout.
- The cycle is repeated.

Advantages of alley cropping:

- Improvement of soil fertility and structure and micro-climate conditions, thereby benefiting crops.

- A longer cropping period and higher land use intensity.

- Trees used can provide products of commercial and subsistence value.

Disadvantages:

- The technique will take some years to establish, so farmers will have to wait for the benefits.
- Farmers may not have the capital available for the investment in trees.
- Alley cropping requires considerable labour and management - results will be poor if planting and pruning schedules are not carried out properly.
- Competition with crops for water and nutrients. It is important to plant trees with deeper roots than those of the crops grown alongside.

iv) Contour vegetation strips

Contour vegetation strips are living barriers of trees and shrubs which are planted along the contour lines of a slope, in order to control water and soil erosion. These lines of vegetation can also provide useful products such as food, fuel, building poles, fodder or gum.

There are many factors to consider when building contour strips as bad design can lead to even more severe erosion. The effectiveness of the vegetation strips depends on the type of trees planted, the spacing of the trees and the width of the strip, the steepness of the slope, the amount of rainfall and the soil type.

Advantages:

- Strips can provide additional nutrients and organic matter into the soil. This can be increased by using nitrogen-fixing plants.
- Excess vegetation can provide food for animals. These can be allowed to browse through the strip to feed on crop remains after harvesting.

Disadvantages:

- Contour strips take up land which could be used for crops.

CHAPTER 13: PRINCIPLES AND PRACTICES IN LIVESTOCK PRODUCTION

1. Introduction to livestock production

This is a broad area that encompasses all major areas in animal production. It ranges from the rearing of young animals which will become adults in later years. Animal husbandry relies on understanding the needs of both the farmers and the animal welfare. It is based on four main pillars which when followed ensures profitability and sustainability.

These 4 pillars are:-

- Nutrition i.e. feeding with proper feeds in terms of quality and quantity.
- Breeding i.e. use of the right breeds for reproduction.
- Animal health and welfare (housing, stress-free environment)
- Marketing of products.

Ecological animal husbandry principles

1. Diversification of species

This is where different types of animals are kept in a farm for food and income.

This system of farming is important because:

- These animals are considered for generating income.
- They produce manure which, when mixed with other farm materials, will give plants rich food
- These animals will act as security to farmers e.g. when a farmer wants to sell an animal he will just
- choose one animal from his diverse animals unlike the farmer who owns only one type of animal.

- There is plenty of food e.g. meat, milk and eggs.

There are several reasons for keeping farm animals:

- Farm animals provide nutritious food in form of meat, milk, eggs and, therefore, contribute to a balanced diet of the farm family.
- They provide useful products that can be sold to the manufacturing industries such as horns, bones, hides and skins, giving the farmer extra income.
- Animals are a source of financial security; in urgent cases, the farmer can sell some of the animals to get money.
- Oxen, donkeys and horses provide draught power for soil cultivation and transport.
- Sheep and goats can be utilized to graze on range lands that are not suitable for soil cultivation, hence increasing utilization of space on the farmland.
- Animals provide manure that is rich in nutrients and makes a highly valuable farm own fertilizer or a valuable source for making compost.
- On a farm that produces crops, animals can feed on crop remains and other waste products from harvesting, and thus contribute to recycling nutrients within the farm to feed the soil.

Types of animals for diversity

The following animals may be kept for diversity:

- Cows – provide milk, meat, manure and skin.
- Pigs – for pork, bacon, manure
- Shoats – mutton, milk, fur, manure

- Chicken – for meat, eggs, manure
 - Rabbits – for fur, meat, manure
 - Ducks – for meat, manure, eggs
2. **Low external initiatives in nutrition and housing.**
 3. **Ecologically sound range land management.**
 4. **Observation of animal welfare.**
 5. **Health maintenance i.e.**
 - Preventive – Sanitation, good nutrition.
 - Welfare – Stress free, proper housing.
 - Use of complimentary and alternative medicines.

Animal welfare

In order for the animals to be of maximum benefit to the farmers, utmost care should be given to ensure their welfare is taken care of.

The following guidelines should be followed:

- Ensure animals are never harassed in any way.
- Be very friendly to the animals such that they are happy when they see you.
- They should be given as much comfort as possible. The sleeping area should be as comfortable as possible through use of sawdust or other bedding materials available in the farm,
- The feeding and walking area should always be dry to prevent diseases like foot rot and pneumonia.
- Keep the animals according to their nature.
- Give the animals proper feeds in terms of quality and quantity. Clean water should always be available to them.
- Immunization against disease outbreaks should always be a priority.
- Diseases should be diagnosed early to avoid serious effects. This is done through close monitoring of the animals daily.
- The farm workers should be made to understand that no harassment of animals would be entertained and can lead to their immediate dismissal without notice.

- If the cows / animals are under zero - grazing, they should be let out of the zero grazing muscles and also exercise for maximum production.
- Most important animals should be kept according to their nature in order to meet their basic needs and behaviors thus:

Poultry

- Provide perching by providing perching rails
- Provide them with some sand for easier digestion
- Hang some green vegetables 0.5m above the ground
- Provide a dark nest or box for laying

Goat

- They are browsers so hang fodder for them

Pigs

- Roofing – provide an open ground
- Hang chains and old tyres for good exercise

Cattle

- Provide large bulky forage at least 18 – 25 kg per meal, three times per day.

2. Role of animals/ livestock in sustainable ecological agriculture

Integrating animal husbandry into crop producing farms is one of the principles of organic farming. In temperate and arid zones, animal husbandry plays an important role in the recycling of nutrients, while it is less emphasized in the humid tropics. The caring, training, and nurturing of animals is considered an art in many farming communities.

Integrating animals into a farm help creating a closed or semi-closed system where energy and nutrients are recycled. Animals can convert non-edible biomass (e.g. grass, straw, kitchen waste) into food, while increasing soil fertility with their manure.

Many farm animals have a multi-functional role:

- Produce dung which is of great importance for soil fertility.
- Yield products such as milk or eggs for sale or own consumption continuously.

- Recycle by-products such as straw or kitchen waste.
- Serve as draught animals for tillage or transport.
- Produce meat, hides, feathers, horns etc.
- Serve as an investment or a bank.
- Help in pest control (e.g. dugs) and weed management (e.g. grazing on barren fields).
- Have cultural or religious significance (prestige, ceremonies etc.).
- Produce young stock for breeding or sale.

The significance of each role will vary from animal to animal and from farm to farm. It will also depend on the individual objectives of the farmer.

3. Fodder establishment and management

For any animal husbandry practice to succeed, one has to plan in advance where the fodder for the animals will be coming from. Remember that many smallholder farmers practice zero-grazing due small size of land.

Before starting any animal production enterprise, you must have enough fodder either in the fields or already stocked as reserves. One should note that the zero-grazed animals are exactly like a month-old baby who entirely depends on you for everything. You are like their God and they are like your prisoners waiting for whatever you bring to them.

In most smallholder farms, fodder cultivation will compete for space with the cultivation of crops.

Whether fodder cultivation (and thus animal husbandry) is economically more beneficial compared with crop production must be assessed case by case. However, there are some options for integrating fodder crops in farms without sacrificing much land.

Fooder crops are grown specifically for feeding livestock. Fodder is fed in either green(fresh) or dry state.

Below are some examples fodder crops:

1. Grass
 - Nappier grass (*penisetum purpureum*)
 - Bana grass- a cross between *p.purpureum* and *p.typhoides*
 - Setaria
 - Rhodes(*chloris gayana*)
 - Guines grass
 - Star grass
 - Thatching grass
 - Columbus grass
 - Sudan grass
 - Kikuyu grass
2. Legumes
 - White clover
 - Desmodium
 - lucern
3. Green parts of the tree, shrub for example leaves or sometimes flowers and pods, eaten by browsing or grazing animals.
 - Acacia,
 - Leucaena,
 - Prosopis
 - Calliandra,
 - Sesbania
 - Gliricidia etc

So if you want them to deliver the best, you should also give them the best in return. It is therefore worth nothing that the production from the animals is directly proportional to the quality and quantity of the feeds allocated to them.

The type of fodder given to the animal is grouped into three main categories:-

- Dry feeds e.g. hay, crop residues after harvesting (stalks etc) Dry feeds include the use of hay. The best type is that from Boma Rhodes, star grass, desmodium or Lucerne.

- Green feeds e.g. pasture (grass, Lucerne, desmodium etc.
- Silage

Criteria for selection of fodder species:

- Edible to livestock and rich in protein
- Easy to manage
- Drought tolerant
- Tolerant of trampling if to be grazed
- Able to resprout easily

For the cow in particular, the fodder should be supplemented with concentrates in the ratios proportional to the amount of milk they produce.

The fodder should be planted before the onset of rain to maximize on their establishment and faster maturity.

Hay making

- -Harvest grass e.g. Rhodes, kikuyu grass etc after 4-6 weeks of re-growth or just after flowering and seed production when the nutritive value and dry matter yields are equal
- -Mixture of grasses and legumes with a lot of leaves is ideal because they increase digestability and feed intake.
- -Dry the cut pasture as quickly as possible in 2-3 days during the dry season or one week in the cold season
- -Once dried, the product can be stored loose or in bale stacks in the field or in the barn.

Box hay Baling

This is simple manual method of producing bales of hay. Small-scale farmers may be interested in this technology because hay is both easier to store and easier to transport when it has been baled. Also, baled hay retains a higher nutrient content than hay that has been cut and left exposed to the sun.

The bales are pressed in a wooden box with no bottom. Compression is achieved by using a lever arm and tamp attached to the wooden box. Attach the lever arm with a pin that is substantial enough to withstand the pressure applied to the hay.

Dimensions and materials can be modified in order to suit local needs.

Size

The standard hay-baler is 24 x 24 in (0.6 x 0.6 m) and the depth is 19 in (48 cm). The lever arm is 5 ft(1.5 m) long and the point of attachment between the tamp and the lever arm is 19 in (48 cm). The following pictures and notes explain the procedure for using the hay-baler.

Procedure

- Cut narrow slots in the middle of the top edge of each wall. Insert twine into the notches and run the twine across the ground and out through the notch on the opposite side. Be certain to leave enough twine hanging out for cinching and tying once the bale has been compressed.
- Fill the box with hay that has been cut and dried.
- Compress the hay using the lever and tamp. The tamp should be attached to the lever with a bolt that allows it to pivot for a good fit all the way down.
- Continue to refill the box and compress the hay until the bale is the desired tightness.
- Once the bale has been compressed, lift up the tamp and tie off the bale with the overhanging twine.

Silage

It is the fodder we get from green maize, Napier grass, cow candy, Lucerne, etc. These are cut while still green before they start drying and chopped into small pieces. The pieces are then put into a silo and compressed to remove as much air as possible.

Alternatively, they can be stored in airtight

containers after serious compaction. This prevents rotting and helps in facilitating fermentation. The most ideal material to use is the 1000 gauge polythene sheets. Molasses is also added to the silage to feed the bacteria and also increase the quality of the silage. The best silage is olive green in colour. It is stored for 2-3 weeks before being opened for use by the animals.

Silage making

Method 1

A method of preserving green forage by controlled fermentation.

Materials used; Napier grass, maize, sorghum, sugarcane tops etc.

Requirements: Ensiling materials, water, molasses, 1000 gauge polythene.

Procedure

- Harvest material and chop into small pieces about 2cm.
- Dilute molasses with water at the ratio 1:3 and sprinkle on the chopped pieces when spread or as you put in the bag.
- Tie one end of the polythene bag and start packing and compact the pieces well.
- When full, tie and put heavy objects e.g. stones to put away air.
- Ready for use from 3-8 weeks.

Feeding

- Introduce gradually to make the animal used.
- Feed after milking to avoid smell in milk.
- Cover after getting days' ration.

Method 2

Trench Silo Silage Making

- Dig a pit should be smaller at the bottom than at top i.e. should be slanting.
- Align the sides and bottom of pit with a polythene sheet - to avoid contact with soil.
- Cut the crop to be ensiled (fodder) and leave to dry in the sun for 2 – 3 hours, then chop into small pieces about 2 cm in size.
- Mix molasses and water in the ratio 1:3

- Place chopped materials into the pit spread uniformly into layers of 30 cm thick
- 6. Sprinkle water molasses mixture and compact thoroughly NB: Use watering can for uniform distribution of solution
- Repeat step 5 and 6 until the pit is full then cover with a polythene sheet finally cover with soil /mud to prevent air and water

Concentrates

Concentrates are feeds which are high in energy but low in fibre i.e. < 18 % crude fibre. They contain a high level of a particular nutrient e.g. carbohydrates or proteins. Their use depends on price and availability.

Concentrates can be substituted with locally available materials such as:- grains (maize, sorghum, barley, wheat etc, By-products (Molasses, crop tops, bagasse), Protein Supplements with > 20% crude proteins e.g. slaughter house by-products such as (meat meal, feather meal, cotton seed cakes, fish meal, bone meal, groundnut cakes)

4. Livestock Management

Farmers should try to manage healthy farm animals to produce satisfyingly over a long period of time. To achieve this goal, various needs of farm animals have to be considered:

- Fodder in adequate quality and quantity; for non-ruminants: diversity in fodder is usually required.
- Sufficient access to clean drinking water.
- Clean sheds of sufficient size and with adequate light and fresh air.
- Sufficient freedom to move around and perform their natural behaviour.
- Healthy conditions and veterinary follow-up, when needed.
- Sufficient contact with other animals, but no stress due to overcrowding.
- For herd animals: an appropriate age and sex distribution within the herd

Breeding

Over the last decades, traditional breeds have been replaced by high performing ones in many regions. Similar to high yielding plant varieties,

these new breeds usually depend on a rich diet (concentrates) and optimal living conditions. As high performing breeds in general are more susceptible to diseases than traditional varieties, they need frequent veterinary interventions. Thus, these new breeds might not be the right choice for small farmers, as the costs of food concentrates and veterinary treatment are too high compared with what can be earned by selling the products.

Breeding activities therefore should try to optimize the overall performance of the animal, taking into consideration the different goals of an ecological farmer. For example a poultry breed suitable for smallholder farms might not be the one with the highest egg production, but one in which meat production is good, and kitchen wastes and whatever is found on the farm yard can be used as feed. Suitable cattle breeds would produce sufficient milk and meat while feeding mainly on roughage and farm by-products (e.g. straw), be of high fertility and good resistance against diseases, if required, they can also be used for draught and transport.

Livestock housing

The type of shed should be specific to the type of livestock to be sheltered. Poultry, for instance, should be housed in sheds that do not get too hot. Contact of the animals with their faeces should be avoided as much as possible.

The combination of animal husbandry and farm activities requires control of their movements so as to avoid damage to crops. For the welfare and health of the animals, sheds must be cool and aerated, and protect from rain

They should be constructed in a way ensuring:

- Sufficient space to lie down, stand up, move and express natural behaviour (e.g. licking, scratching etc.).
- Sufficient light (as a rule, one should be able to read a newspaper in the shed).
- Protection from sunlight, rain, and extreme temperatures.
- Sufficient aeration, but no draught.

- Appropriate beddings (see section below).
- Elements to exercise natural behaviour (e.g. for poultry: perching rails, sand baths and secluded laying nests).
- Sheltered pits or heaps to collect and store manure.

Animal housing should aim to create an environment that offers protection from predators, heat, rain and theft, be easy to manage and have as much free movement as possible. For example, animals can spend the day freely feeding in an enclosed area and then be housed during the night. If livestock is partially kept in an animal house, this makes it easier for the farmer to monitor the amount of feed and water consumed by the animals, as well as to collect dung, droppings and urine.

Part-housing also gives the opportunity to carry out health treatments such as de-worming and external parasite control and to closely observe the animals' behaviour.

Appropriate housing on ecological farms aims at ensuring that animals have:

- Adequate space for the size and number of animals to allow for free movement, lying and resting. Animals need to express their natural behaviours, for example, pecking or digging in the ground, climbing or scratching.
- Sufficient fresh air and natural daylight, which helps prevent breathing problems and spread of infections.
- Protection against harsh weather conditions, for example, excessive sunlight, heat, rain and wind. Such unfavourable weather conditions facilitate the development and spread of infections and may stress the animals rendering them more susceptible to infections.
- Natural bedding material where animals are kept clean by avoiding direct contact with the wet ground or floor. The bedding will also absorb urine and faecal material, making it easy to collect.

- Permanent provision of clean water and routinely cleaned feeding troughs to provide clean feed.
- Security against predators without compromising the ventilation requirements and free-range housing.
- Protection from any spiky or dangerous elements to avoid injuries to the animals and the farmer.

For economic reasons, sheds can be built with simple, locally available materials

Beddings

Beddings are materials used in sheds for keeping the floor soft, dry, and clean, which is important for animal health. They absorb the excrements of the animals and need to be re-placed from time to time. Beddings can be of straw, leaves, twigs, husks or other locally available material. They can be replaced daily or kept for several months while adding fresh material on top.

Construction of animal housing

Animal houses should be constructed in a simple way using locally available materials as much as possible to save on costs.

The following examples provide some valuable information for specific livestock housing designs based on the species' natural behaviours:

- Poultry, especially chicken, enjoy perching at night and, therefore, perching rails should be provided for this purpose. Chickens enjoy playing in dust baths to clean their bodies. Dark, secluded nests should be provided for layers, as they prefer laying in such places. For flying exercises, the housing should have a provision to suspend green vegetables about 0.5 m off the ground. Poultry also like to scratch for ants and worms, as this is their natural way of looking for food. Thus they should be given access to open ground in proximity to the poultry house.
- Pigs naturally prefer separate spaces for resting, feeding and for relieving

themselves, thus their housing should provide such separate spaces. They also like to have access to a wet and muddy area for cooling their bodies, especially in hot environments. They furthermore enjoy brushing against the walls, so the wall should be stable and not too rough so as to cause bruising or other injuries. Pigs should be given natural materials to play with such as wood logs, twigs or straw.

- Goats enjoy feeding on suspended forage, high enough so that they can attain an upright posture while feeding. They also like to climb, thus parts of their bedding can to be raised off the ground so they can use different layers. The social structure of goats is quite strict; therefore, they need different individual places and corners where low and high ranking animals can feed separately.
- Cows are big animals, sometimes with big horns and enjoy lying down while chewing cud (ruminating). They, therefore, need enough space to stand, turn, go past each other and lie down. If they get fed in the cow shed/kraal, every animal needs to have enough space to feed without being disturbed. A gently sloping floor is necessary to allow easy drainage of large amounts of urine through a drainage channel to a paved drainage pit outside the cattle kraal.

Feeding and nutrition

The availability of fodder is one of the limiting factors in animal husbandry. Unlike landless systems in conventional farming, ecological farms animal husbandry should be mainly based on the fodder produced on the farm itself. As is the case with humans, there is a direct link between the quantity and composition of the food and the health status of the animals.

If farm animals are to be productive (milk, eggs, meat etc.), it is important that they get suitable food in sufficient quantities. If the fodder production of one's farm is limited (which usually is the case), it might be economically valid to keep less animals but supply them with sufficient food

The appropriate quantity and the mix of feed items will of course depend on the type of animal, but also on its main use (e.g. chicken for meat or egg production, cattle for milk, meat or draft etc.).

In milk production for example, cows producing milk should be given feeds with high dry matter content and possibly other feed items of sufficient protein content. On the same diet, draught animals would rapidly become exhausted.

A balanced diet will keep an animal healthy and productive. Whether or not a farm animal receives the appropriate amount and kind of fodder usually can be seen by the shine of its hair or feathers. For ruminants, a majority of the fodder should consist of roughage (grass, leaves). If concentrates or supplements are used (e.g. agricultural by-products and wastes), they should not contain growth promoters and other synthetic substances. Instead of buying expensive concentrates, there are a variety of leguminous plants rich in protein which can be grown in the farm as cover crop, hedges or trees. If mineral content in the available fodder is not sufficient to satisfy the animal's requirements, mineral salt bricks or similar feed supplements can be used as long as they do not contain synthetic additives.

Feeding requirements for animals

Like human beings, animals depend on different types of foods to grow and produce well. Different animal species need different feeds. The daily ration for any farm animal should contain an average composition of 7 parts carbohydrates, 2 and half parts proteins and half a part of vitamins, minerals and oils.

Carbohydrates provide animals with energy for their exercises, production, grazing and doing work for human beings. For example, a donkey needs energy to carry goods. Roughage feeders, like cattle, goats, sheep, camels and donkeys are able to obtain their basic carbohydrate requirements from pastures.

Non-roughage feeders such as pigs and poultry obtain their carbohydrates mainly from cereal grains such as maize, sorghum, and their industrial by-products like maize bran. Tubers such as cassava and sweet potatoes are also used as a source of energy for those animals. Feeding of grains and tubers in ruminants should be restricted to high producing animals (for example, at the beginning of lactation) and to an average of 1 to 2 kg per day for big animals like cows and 100 to 200 grams for small ruminants like sheep and goats, to avoid excessive production of acids in their rumens during digestion. Such animals naturally do not depend on such feed. Grains should be reserved for human consumption as much as possible.

Protein is needed in the animal's body for growth and repair of tissues. Lack of protein in the diet leads to poor growth rates, reduced yield of animal products, loss of weight and late maturity for growing animals. Leguminous fodder is a good source of protein for most animals. Free-range chickens are able to obtain their proteins by picking ticks, insects and worms from the environment. Earthworms for feeding chickens can be multiplied by mixing a small amount of the soil containing earthworms with fresh cow dung and dry leaves in half a drum, which is kept moist by covering with a sisal sack. The worms multiply quickly and after about two to three weeks they can be harvested and fed to the chickens. Pigs can be fed with human leftovers, which may contain protein from human diets.

Vitamins are only needed in small amounts in animals, mainly for boosting their immunity. They are plentiful in young green pasture or fodder, kales, young amaranth that have not yet seeded, and in fruit peels from the kitchen.

Minerals are essential in the animal body for different functions. For example calcium and phosphorus are necessary for eggshell formation, bone formation, muscle contractions, synthesis of hormones and enzymes. Their deficiency results in reduced growth, soft brittle bones that fracture easily, difficult births, low egg and milk

production, retained afterbirth, etc. When animals lack some of these minerals, they develop the 'Pica' habit, which leads to eating strange things such as cloths, rags, bones, soap and metal sheets.

Minerals are available from some plants like amaranth (pigweed), stinging nettle (*Urtica dioica*), black night shade (*Solanum nigrum*) and pumpkin leaves (*Curcubita* spp.). Mixing equal parts of dry leaves from these plants and grinding them to a smooth powder will provide for most minerals in animals when placed in a mineral box and fed as often as possible. Salt (NaCl) should also be given to ruminants.

Fats and oils provide a layer of insulation below the skin for protection against the cold. They also facilitate the absorption of vitamins in the body.

Sunflower seeds provide a good source of fat for (cattle), pigs, poultry and rabbits. Cottonseed, sunflower, sesame or peanut cakes, after extraction of oil, are also good sources of fat. Ruminants can build fat from roughage.

Water- While water may not be treated as a true nutrient, it is essential for providing a medium through which other nutrients are absorbed and assimilated in the body. It is also responsible for giving shape and turgidity to most tissues of the body. Clean water, which is free from contamination with chemicals and disease causing agents, should be provided to the animals all the time. Salty water with a lot of natural minerals is not suitable for livestock as it limits water intake.

Livestock health- Pest and disease management.

Disease causing germs and parasites are present almost everywhere. Like humans, animals have an immune system which is usually able to cope with these germs. And as with humans, the efficiency of the immune system will be disturbed if animals are not properly fed, cannot practise their natural behaviour, or are under social stress.

Health is a balance between disease pressure (the presence of germs and parasites) and the resistance (immune system and self-healing forces) of the animal. The farmer can influence both sides of this balance: reduce the quantity of germs by maintaining good hygiene, and strengthen the animal's ability to cope with germs

Similar as in crop health, sustainable animal husbandry puts the more emphasis on preventive measures in order to keep animals healthy, rather than on curative methods.

- keeping robust breeds rather than high performing but very susceptible ones.
- the conditions in which the animals are kept should be optimal ones: sufficient space, light and air, dry and clean bedding, frequent exercise (e.g. grazing) and proper hygiene.
- The quality and quantity of fodder is of crucial importance for the health of the animal. Instead of feeding commercial concentrates which make animals grow faster and produce more, a natural diet appropriate to the requirements of the animal should be achieved.

Where all these preventive measures are taken, animals will rarely fall sick. Veterinary treatment thus should play only a secondary role in sustainable farming. If treatment is necessary, alternative medicine based on herbal and traditional remedies should be used. Only if these treatments fail or are not sufficient, synthetic medicines (e.g. antibiotics, parasiticides, anaesthetics) may be used

The main principal for sustainable animal health is: get to know the causes of (or factors that favour) diseases in order to enhance the natural defence mechanisms of the animal (and to prevent its manifestations in the future).

On the other hand, there are natural herbal remedies and traditional treatments used in animal

treatments. These remedies are easily available and cheap.

They include:

- Dietary additives like vitamins and minerals.
- Botanical dewormers such as garlic, pumpkin seed and worm wood (*Artemisia* spp.) that can be added in animal feed to manage gastrointestinal nematodes, and lung and liver parasites.
- Neem seed oil, tephrosia or pyrethrum to control ticks.

Causes of poor health in animals

There are different possible causes for poor health in animals:

- Poor feeding, both in terms of quality and quantity, affects animal health and performance as well as the ability to resist disease infections. It further causes metabolic disorders like acidosis, milk fever, acetonaemia and pasture bloat in cattle caused by nutritional imbalances of minerals, vitamins, protein and energy supply from feed.
- Poor hygienic conditions of the animal housing provide good breeding grounds for a number of parasites and other disease causing organisms. Feeding troughs contaminated with animal faecal material is a very common source of infections.
- Endo-parasites like nematodes and other worms, and ecto-parasites such as lice, ticks and mites cause infections, which reduce feed intake, and the rate at which the food is broken down inside the body for its different functions. This again affects body weight gain, production and reproductive performance of the animals.
- Injury to the animal due to poor handling or exposure to dangerous physical materials such as glass and metal can result in infections that weaken the animals.
- Disease causing organisms (pathogens) and parasites that are transmitted when infected animals, human beings and

equipment or materials are moved from one flock or farm to another.

Preventive measures in animal health management.

Organic management of animals primarily focuses on precautionary and preventive measures, which include:

a. Proper selection of suitable animal breeds

The breed of the animal is the starting point in successful organic animal health management. Only breeds adapted to local conditions in terms of feed requirements, weather, common parasites and disease tolerance should be chosen. This will minimise the cost of management as well as the risk of losses due to deaths.

b. Quarantine measures

Any new animals introduced in the farm should first be well treated and isolated for a while to allow for closer monitoring of their health status. Movement of any materials including manure, and equipment should be restricted from areas and farms unless the healthy status of such farms is ascertained to be safe. Visitors to the farm should also sanitise their feet before moving into the animal houses or grazing areas to minimise transfer of infections.

c. Regular monitoring of animals

Close observation of animals is important to identify and treat infections before they worsen or infect other animals. Thus organic farmers keep daily or frequent records to assist in assessing possible signs and causes of the diseases or injuries. Signs of illness may include reduced appetite resulting in reduced feed and water intake, reduced productivity or, for example, a drop in milk or egg production, apathy observable as a lack of vitality, head down or abnormal movement, abnormal discharge from bodily orifices, difficulty in breathing observable as fast, laboured, coughing, and gasping, inflammation of mucus membranes in the mouth, conjunctiva, and vulva lips, where the membrane may be pale or dry in cattle, rise or drop in body temperature,

excreta material may become different from normal, either too hard, too watery or may be covered with mucus or blood. Heavily infested animals can be separated from others or, as a final measure be slaughtered so that they do not infect others. The meat should only be eaten if the animal's body temperature is normal and there is no abnormality in the meat, otherwise it should be buried away.

d. vaccination

Vaccination is recommended especially for diseases that are difficult or impossible to cure and which cause great losses by causing high mortality rates.

Examples of such diseases include foot and mouth disease, anthrax, pneumonia, African swine fever and avian influenza. For certification, organic standards classify the use of vaccines as restricted. This means that their routine use is discouraged and is only permitted when it can be demonstrated by the organic farmer that a specific disease is endemic in the region or on the organic farm, or where their use is required by law or if a veterinarian recommends it. Organic certifiers will, therefore, require written verification from a veterinarian to confirm the presence or threat of disease infection. In addition, the vaccines must not contain genetically modified ingredients or by-products. The use of vaccines under these circumstances will not prejudice certification and does not require quarantine procedures, but full records of treatments must be kept.

Poultry management

Kenya has an estimated 30 million birds of which 76% are indigenous, 13% broilers, 6% hybrid layers and 2.2% other species. Indigenous chicken are kept by 90% of rural households while broilers and layers are mainly reared by urban and peri urban areas by farmers targeting the ready market. Other poultry are kept by farmers with special interests.

Though the chicken scene in Kenya currently has a limited amount of common breeds namely the

hybrid layers, hybrid broilers and indigenous chicken, also other breeds exist such as bantam chicken and others. A chicken manual from USA1985 (Haynes, 1985) indicates the following breeds existing in that country and from which the common hybrids are bred

Management of hybrid layers

Hybrid layers are typically kept near good markets for eggs (such as towns) where space may be limited, and ready made feed is easily available. Layers may be kept in individual cages, but more often in Kenya are kept in large houses with free movement within the chicken house, and some structures for perching. All creatures need exercise to be happy and healthy, also chicken. The young chicks are bought from commercial hatcheries as day old chicks, and reared in the facilities set aside.

Management of broilers

Broilers kept for meat production, are also hybrid birds and the chicks need to be bought commercially, as farmers do not have access to the parent breeding stock. The same commercial hatcheries listed under 'Layers' usually also have broiler chicks for sale.

Broiler hybrids are very fast growing birds and need specially manufactured feeds. It will not work to try and rear broilers on any other feed than the specially made one from reputable companies.

Broilers can be kept in similar confinements as layers, but do not need the laying boxes. Because they grow heavy enough for slaughter in 6-8 weeks, their bones are sometimes weak. To keep them healthy and bones as strong as possible, it is good to provide exercise areas, even outside. Also broilers like some sunshine, which reduces stress in the flock and helps keep the birds healthy.

Management of indigenous chicken.

Village chicken production systems are mostly based on the local scavenging domestic fowl (*Gallus domesticus*), which predominates in African villages. Sometimes the productivity of

these birds is very low, but with proper management practices indigenous chicken can become very productive and has a very good potential for improving the income of the owners.

Village chicken systems in rural Africa are characteristically:

- an indigenous and integral part of the farming systems, with short life cycles and quick turnovers
- low input production systems
- a means of converting low-quality feed into high quality protein

In order to improve such low input - low output systems a number of factors need to be considered

Breeding

Introduce one new cock for every 10 hens every two years, in order to avoid inbreeding. Improved indigenous chickens for improving the local breeds can be bought from Naivasha research station in Kenya as well as from private breeders.

In the village setting care must be taken to protect brooding hens from predators, rodents and other forms of stress. If a brooder hen is well protected and comfortable she can easily hatch 15 eggs per sitting. A brooding cycle takes minimum 18 days after which the first eggs should start hatching. The mother will normally keep the chicks with her for a day or two before taking them to food and water. Any eggs not hatched after this will go cold and most likely not hatch. It is highly advisable to keep food and clean water available near the brooding hen during this whole period for her to hatch the maximum amount of chicks

Selection of eggs for setting

A improved nutrition can raise the average quantity of eggs laid per clutch by 100%. For a successful hatching, the eggs must be handled carefully from laying till setting. Eggs should be stored with the broad end facing upwards, as at this end there is an air sack, through which the egg breathes. Eggs should be stored in a clean and dried place to prevent rotting. Since fertile eggs

grow slowly, eggs older than 14 days should not be used for hatching.

The reproductive cycle

By shortening the reproductive cycle, hens lay eggs earlier and double the number of clutches per hen per year. Improved management increase the survival rates of the chicks. Shortening of the reproductive cycle can be achieved by better feeding, protection from predators and rodents, timely vaccinations and deworming, control of external parasites, and culling of aggressive and unproductive birds.

Serial hatching

Poultry can be used to sit on eggs continuously for two or more times by removing the chicks every time they hatch and replacing them with new eggs. Ducks can sit on 30 to 35 eggs and can be used for up to six consecutive times. Combining serial hatching with synchronisation (see below), more chicks will be able to hatch without using an incubator. Turkeys are also excellent chick brooders and can raise up to 50 chicks at the time.

Synchronised hatching

When hens that started laying within the same week get brooding, the first hen to reach this stage can be delayed by being given one egg to sit on. This will be repeated for the second and third hens, so that all the hens are set on one day. By the time of setting, all 'dummy' eggs should be destroyed. The time between the first hen and the last should not be more than one week. Chicks hatching on the same day fit in well with feeding and vaccination programs.

Housing Poultry are often allowed to scavenge for food in the local environment during day time, getting housed in the evenings. In some cases they roost in the branches of trees or in enclosed baskets in the house to protect from predators and theft. In other cases, keepers build wooden, stone or brick accommodation attached to the family dwelling house. As brick houses tend to be difficult to keep clean, They present a potential threat due to the build-up of pathogens.

A good housing should be spacious, well illuminated, dry and airy, easy to clean and have perches for chicken. It should be used in free-range poultry farming system to protect chicks from predators and bad weather.

Hygiene

- Dry and clean housing is essential for diseases not to spread or develop.
- Before the poultry litter is brought into the house, houses and shelters should be cleaned and disinfected with lime wash or other disinfectants.
- As soon as the flock has been moved out, then remove manure, clean and disinfect loose equipment and houses.
- Cull all birds that are unthrifty and out of production.

Space

- Too many birds kept together may cannibalise/wound or even kill each other, as the stronger ones peck the weaker.
- Do not keep local breeds in confinement without free access to outdoor areas.
- Provide a space of 5 square meters per adult bird in a run system.
- When space is limited, diseases are passed more easily from one bird to another.

Feeding

- Supplementary feeding in particular for small chicks, is one of the most important means of preventing diseases.
- Store Feeds in a dry and clean place always to avoid contamination and spread of diseases.
- Provide your poultry with clean water daily to avoid the spread of waterborne diseases, such as Fowl Cholera. Daily addition of EM to drinking water has been shown to help prevent diseases.

Proteins

Poultry need proteins for growth and production. Feed rich on protein include yeast, 'Busaa' waste (dregs (*Machicha*)), sunflower cake, heat-treated soya or ordinary beans, lucerne, peas, lupins, fishmeal (*Omena*), dried blood, rumen content, earthworms and termites. Termites are trapped by

slightly watering leafy waste such as maize stover and rubbish collected from the compound and leaving them outside for two or three days

Minerals

Minerals are trace elements that can be found in plant seeds and grate. Calcium for example, which is important for bone and egg shell formation, is found in fishmeal. Deficiencies of minerals, especially in calcium, will cause problems with egg-shell quality and thus decrease hatchability and increase fragility of the eggs. Minerals supplements can be given as part of the improved feeding systems.

Vitamins

Vitamins are necessary for growth and reproduction. The yellow pigment in the skin and egg yolk of indigenous chicken shows the presence of carotenoids from fresh vegetation such as grass and vegetables, which include vitamin A. Deficiency of vitamins is likely to cause illnesses and reduced hatchability in eggs.

Water

Scavenging poultry can get diseases by drinking water from small ponds or puddles, as these can transfer water borne diseases and parasites.

Poultry should get clean and fresh water all the time at the same place. This makes it is easy to medicate them.

Farmers who regularly add EM (effective microorganisms) or BM to the drinking water of chicken are reported to have very few cases of coccidiosis and other diarrhea causing pathogens.. Also vinegar can be used as a water additive if signs of diarrhea appear in the flock.

Other feedstuffs

Algae and water plants material have been considered appropriate for feeding poultry since they provide carotenoids and other fat-soluble vitamins. The carotenoids improve the colour of the egg yolks and together with vitamin E enhance the egg quality and the viability of the hatchlings. The deeper the egg yolk colour and pigmentation,

the greater is the supply with vitamin A to the consumer

Where available, the mixing of dried molasses with protein feeds have been shown to improve nutritional status of chicken.

Dung heaps from the waste of cattle, goats and sheep are also excellent sources of insect protein but also may act as sources of parasites (e.g. coccidia) and other diseases.

Chicken diseases

What causes diseases?

- Microorganisms
- Parasites (Internal and external)
- Malnutrition
- Injuries
- Chemical (eg. Sodium chloride poisoning).

Disease outbreak and death of the animals depend on their age, nutritional status and hygiene of their housing.

Characteristics of healthy birds:

- Alert and on guard.
- Bright eyes and comb.
- Walk, run, stand and scratch.
- Continuously eat and drink.
- Normally lay eggs.
- Normally smooth and neat feathers.
- Soft compact droppings breathe quietly.

Characteristics of unhealthy birds/sick birds

- Tired and lifeless
- Dull eyes and comb
- Sit or lie down
- Eat and drink less
- Lay less or stop laying eggs
- Ruffled and loose feathers
- Wet droppings with blood or worms, diarrhea
- Cough, sneeze and breathe noisily.

Health and disease management

- Starts at the hatchery and continue to maturity.

- Poultry well fed and managed and effectively vaccinated against known diseases usually remain healthy.
- In case of disease outbreak, sick birds should be isolated and dead birds removed burnt or buried
 - Apply strict sanitary measures in all houses.
 - Notify veterinarian as soon as possible.

Rules for disease prevention

- Vaccinate the chicken as recommended by the vet
- Give access to the right feed and clean water, in particular for small chicks
- Build shelters against wind and rain and predators
- Clean houses regularly and apply lime wash/disinfect the floor and walls
- Provide dry litter regularly where applicable
- Do not put too many birds together
- Different species of poultry for example hens, turkeys, pigeons, ducks and guinea fowls should be kept separate
- Separate chicks from adult birds except from the mother hen
- Vaccinate chicks against the most important diseases and revaccinate if necessary
- Isolate and treat sick birds. If medication is not available then kill the sick birds
- Burn or bury killed birds (do not try to eat sick birds that have been killed - diseases can sometimes transfer to human beings never mind how well they are cooked).

Vaccination regime recommended for commercial chicks, but also applicable to improved management of indigenous chicken (Sigma feeds chicken recommendations):

Age	Vaccinate against	Application
1st week	Marek and Newcastle disease	Ask the vet for instructions

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2nd week	Gumboro	In drinking water
3rd week	Lasota + IB	In drinking water
4th week	Deworming, IBD forte	In drinking water
5th week	Lasota + IB	In drinking water
6 - 8th week	Typhoid	Injection
9th week	Deworming (every 2-4 weeks)	In drinking water
8 - 10th week	Fowl pox	Wing stab
12 - 14th week	Typhoid	Injection
16 - 18th week	Renewed Newcastle (where disease is prevalent)	Optional

Importance of a disease is judged by mortality rates and effect on production. Diseases in poultry are divided into three categories:

- High importance
 - high mortality (more than 30% of the flock)
 - highly contagious and difficult treatment.
- Medium importance
 - medium mortality (10-30%) of the flock and/or difficult treatment.
- Less importance, signifies not common
 - lower mortality and/or easy treatment

Diseases with high mortality (more than 30% of the flock), highly contagious and difficult treatment

- Newcastle Disease
- Avian Influenza (AI)
- Fowl pox
- Fowl cholera (*pasteurellosis*)
- *Coccidiosis* (internal parasites)

Disease with medium mortality (10-30%) of the flock and/or difficult treatment

- *Pullorum* disease (Bacillary white diarrhea)
- Fowl typhoid
- Gumboro (Infectious Bursal Disease, IBD)
- Infectious coryza
- Chronic respiratory disease (Mycoplasmosis)

- Roundworms and tapeworms (Internal parasites)
- Mycotoxicosis (fungal poisoning)
- External Parasites

Not common, with lower mortality and/or easy to treatment

- Marek's disease
- coli infection
- Scaly legs
- Nutritional diseases

1) Protozoan diseases

Protozoa such as *Emiria tenella* (coccidia) are larger than bacteria and can be easily seen under the microscope. Protozoan diseases are caused by poor hygiene and sanitation.

Prevention and control

- Use of EM or BM in drinking water for prevention
- Clean up chicken house and disinfect the area with lime (dusting with whitewash of agricultural lime)
- During outbreaks use coccidiostat mixture in drinking water

2) Bacterial diseases

Bacteria are minute germs that can only be seen under microscopes. Bacterial diseases can be prevented through good hygiene and sanitation. Very common are diseases caused by *Salmonellabacteria*, namely:

- **Pullorum disease.** It is caused by subspecies *S. pullorum* and it is severe by chicks. It is transmitted from hen to chicks during egg formation, contamination of eggs during laying or the chicks get infected from faeces.

Symptoms: dead embryo in eggs that do not hatch; chicks develop wet tails within the first week; whitish diarrhoea, huddling and difficulty in breathing. Mortality can reach 100% in the first two weeks.

- **Fowl typhoid.** It is caused by the species *S. gallinarum* and it affects growers and adult chickens. It is spread

through contamination of feed and water by faeces of infected birds.

Symptoms: decrease in egg production, egg fertility and hatchability; anorexia and dullness followed by sudden death.

- **Salmonellosis.** It is caused by another *Salmonella* species. It affects chicks and adults. It is spread by contamination of eggs at laying or through contaminated feed and water and faeces.

Symptoms: Decline in egg production, egg fertility and hatchability; anorexia and dullness followed by sudden death.

- **Collibacillosis.** It is acute in chicks and chronic in adult chicken. Chicks get contaminated through eggs and contaminated faeces, while feed and water transmit the disease to both chicks and adults. It can be prevented by keeping egg sanitation.

Symptoms: Respiratory distress, diarrhoea, high mortality of chicks and dead embryos in spoiled eggs.

- **Infectious Coryza.** This disease can be acute, mild or chronic. Contamination occurs by faecal matter, aerosols or through feed and water. It can be prevented by vaccination with bacterin in water at 10 to 12 weeks and 16 to 18 weeks.

Symptoms: Swollen watery eyes, nasal discharge, laboured breathing and decrease in egg production. All clinically ill chicken should be destroyed.

Prevention and control

Salmonella and other pathogenic bacteria are present in the air and faeces of most animals, and can even be present in some of the food items bought in the shops. Bacterial diseases can be prevented through good hygiene and sanitation. Which means regular cleaning of chicken houses and runs, regular disinfections with lime, etc. Some diseases such as fowl typhoid can be prevented by vaccinating the birds.

NOTE: Do not vaccinate sick birds.

3) Parasitic diseases

Parasites are organisms that live in or on a host (animal or plant); the parasite obtains nourishment from the host without benefiting or killing the host. Chicken parasites include lice and fleas, and worms living in the opening of organs. They may cause diseases and weaken the immune-system, making the chicken susceptible to other diseases.

Worms

Worms inhabit the alimentary canal and other internal organs such as lungs, trachea, etc. There are two groups of worms: round worms and flat worms.

Round worms

- *Ascaridia galli.* They infect both chicks and adult chicken. Infection occurs through eggs that are laid by female worms in birds' intestines and are passed out in droppings. They mature in one week or longer, and are swallowed up by chicken, hatch and cause new infection. Prevention is difficult due to feeding habits, especially by scavenging chicken.

Symptoms: Slow growth and stunted, culled feathers and drooping head, thirst, low egg production and death due to intestinal obstruction in young birds.

- Gape worms (*Syngamus trachea*). They infect the trachea (windpipe) of chicken. Adult worms live and lay eggs in the birds trachea; the eggs get coughed out or get swallowed into the oesophagus and discarded via faeces. The eggs hatch to larvae which infect chicken or enter intermediate hosts such as beetles and earthworms.

Symptoms: Difficulty in breathing and gasping for air (thus the term gape worm), huddling, and death due to suffocation.

Flat worms

- Tape worm (*Raillietina tetragona*) infests scavenging chicken. The worms release the eggs free or retained in a segment. Beetles and snails ingest the eggs. The eggs

develop in these intermediate hosts infecting chicken that feed on them. Prevention occurs by using clean containers.

Symptoms: Stunting, Thirst, poor health, low egg production and death of young birds on poor diets.

Prevention and cure

Intestinal worms in chicken are controlled by regular deworming with recommended deworming medicine usually mixed with drinking water.

External parasites

The most common external parasites include lice, mites, fleas and ticks. They infest poultry houses and breed in cracks of the buildings. Infestation occurs through infected birds and pets and affect all ages of birds but are severe in chicks. Prevention can be done by maintaining cleanliness of the poultry nests and houses and sealing cracks in the walls and on the floors.

Lice lay eggs on the feathers and suck blood from chicken, causing discomfort.

Mites live in cracks in the poultry houses, not on the host. They suck blood from the birds at night and remain in the cracks during the day.

In severe infections, birds become anaemic.

Fleas suck blood from birds after which they drop and lay eggs in the litter. The eggs mature to adult fleas, which can survive for up to a month without feeding.

4) Viral diseases

Viruses can be prevented by vaccination. They are the smallest germs and can cause incurable diseases.

Newcastle disease

Newcastle is the most economically important and the only notifiable disease in chicken. It is spread by dogs, birds, wild birds and man. Prevention occurs only by early vaccination.

Symptoms: Respiratory stress, lack of appetite, diarrhoea, nervous symptoms and high mortality. Death can also be sudden without symptoms.

Fowl Pox

Fowl pox is a chronic disease in adult birds and deadly among chicks and growers. It is caused by Pox virus and is transmitted by mosquito bites and mechanically through broken skin. Prevention occurs by clearing bushes.

Symptoms: Pimples or scabs on the birds combs, wattle and eyelids, a watery discharge from eyes, difficulty in breathing indicated by whizzing sound and loss of appetite.

Infectious bronchitis

This is a contagious disease, acute in chicks and chronic in adult birds. Transmission occurs through faeces from sick birds, contamination of litter and by air.

Symptoms: Sneezing, watery eyes, nasal discharge, wet droppings, poor egg shell with no death unless from secondary infection. Chicks gasp and cough, breath noisily, have watery eyes and nostrils, become depressed and huddle. Mortality can be as high as 25%.

Avian Influenza (Fowl plague)

This is an acute disease in chicken, turkeys, ducks and wild birds. Transmission occurs through contaminated faeces, water and air.

Symptoms: Respiratory distress, sneezing, swollen head and face, emaciation and nervous disorder. Infected birds must be destroyed and location of infection quarantined.

Infectious Bursa Disease (Gumboro)

This disease is common in hatcheries. It affects young chicken 2 to 6 weeks old and it is rare in indigenous birds. Transmission occurs through feed, water and faeces.

Symptoms: Diarrhoea, sleepiness and depression, ruffled feathers and trembling of the head. Mortality is between 50 and 80%. The disease weakens the immun-system, making the birds more susceptible to other infections. It can be controlled by vaccinating the chicken when they are 2 to 6 weeks old though drinking water.

Chicken/ Poultry Products and Services

Poultry play an important role improving the income of local population and providing high-quality protein (meat and eggs).

Dairy goats' production

Introduction

Traditionally, goats and sheep have played a major role in Kenya/East Africa through the ages. These animals have been the main source of meat and skins, contributing much to the social and economic life of people. Some communities kept milking goats, but these have mostly gone out of production, especially with the arrival of the dairy cow in the 20th century. In ASAL areas milk from goats and sheep still play a major role especially in child nutrition.

These are classified into indigenous and exotic breeds. The exotic breeds are mainly kept for milk. Meat breeds include Galla and Boers (indigenous) while dairy breeds include

- Saanen – White in colour, short fur and no horns. It has high twinning rate.
- Toggenburg – Brown in colour, white lines on face, legs and tail, long fur.
- Anglonubian – White in colour, long dropping ears, medium fur.
- Kenya alpine – Deep brown/black in colour.

Common dairy goat breeds.

Kenya Alpine

The breed has a variety of colors for example Kenya Alpine is brown with a black stripe on the spine and shoulders. Mature males weigh 75-100kgs while females weigh 50-70kgs. She produces up to 4 litres of milk per day.

Toggenburg

Two sub- types exist:

- The British Toggenburg males weigh up to 100kg and females about 70 kg.
- The swiss Toggenburg males weigh about 70 kg and the females about 50 kg.

Purpose: milk production and cross breeding (improving local breeds) The goat is brown in colour with white line on face, legs and tail. Horns in males are long and curved. Natural polling

occurs (lack of horns) Milk production potential: 5 litres/ day under good management

Gestation period: 152 days,

Average litter size: 1.8 Suffer from heat stress in hot climates

Saanen

Purpose: Milk production

The breed is white in colour with pink skin pigmentation. Mature male weighs 80-100 kg while mature female weighs 60-70 kg. It produces up to 7 litres of milk per day under good management and the breed has a high twinning rate. Saanen have no horns. They do not do well in hot climate.

Anglo-Nubian

These breeds are dual purpose and adapts well in hot climates. They are developed from crossing Nubian goat (from Sudan) and English goats. Their colour are whitish /brown with long dropping ears. Mature male weighs 70-110 kg, while female weigh 60-70 kg. It produces 3-5 litres of milk per day under good management. Her milk has high butter fat content (good for cheese making)

Breeding, Inspection and evaluation of a dairy goat

After determining the breed and sex of the goat the next useful step is to examine the teeth. Breakdown of the teeth is a very common reason for culling small stock under range management, as poor quality teeth will affect the ability to browse and feed well. The Galla goats have very strong teeth well able to keep them healthy during a long life. Worn teeth indicate old age. Goats which do not have healthy teeth cannot feed properly, and will not gain weight at the expected rates. Neither will they be good breeding stock. Make sure the lower teeth meet evenly with the upper teeth.

The buck: Do not use bucks with one or no testicles for breeding. Also those with swollen

testicles should be refrained from breeding. A breeding buck should have 2-8 hard teeth. Breeding bucks should have superior qualities, such as body size, muscle conformation (the more muscle the more meat and the more profit). Breeding bucks should have strong masculine necks and heads. A noisy buck is said to be a useful buck.

The doe: The udder should be soft to the touch with two functional teats. Any hardness is a sign the doe has had previous problems most likely with mastitis. A doe with a damaged udder will not be able to produce enough milk to feed her young ones. Look for good strong legs. Weak or bent hind legs will make the goat unable to feed on good browse. Blind females will not be able to find good food in a range style management.

Body condition: Good breeding goats are not thin. Thin goats will not come into heat, if mated they will either abort or reabsorb the foetus into the body at an early stage. Those who manage to give birth will not be able to feed and rear a kid satisfactorily.

Culling: At the start of each breeding season or in the case of ASAL areas, at the end of each rainy season when a drought is expected, a good goat manager inspects his/her flock and determines which ones are to be culled (butchered, sold for meat or fattening by other farmers/pastoralists with more grazing available). Starting with the poorest animals, the following are traits not needed in a prosperous breeding herd:

- females with poor udders
- females who have been barren for 2 or more breeding cycles
- females with a history of aborting
- skinny females
- animals with poor teeth (dry season browsing need good teeth)
- bucks with faulty testicles
- bucks with physical deformities
- shy and timid bucks (seen to be poor breeders)

Age at first mating: Females should have at least two hard teeth (18 months of age) before being mated. If mated younger with too low body weight can result in aborting or inability to feed and care for the kid(s). As a result of such early mating, the female/s body growth will be stunted, and the kids will grow poorly and be of little value.

Mating usually takes place during the rainy seasons, ensuring enough feed for the young ones during the next rainy season.

Gestation period: 148-150 days.

Birth/kidding: There are 3 basic rules in successful kidding management:

1. **Hygiene.** Kidding area must be clean. Make sure the female is in a clean dry place when she gives birth.
2. **Shade.** The kidding should take place under a shelter or shade. A new born kid has a small body size and is born wet. In a cold environment the evaporation of the birth fluids from the skin can drop the body temperature of the kid very quickly, and unless the mother or handler can dry the kid quickly, it will die with cold. In wet cold conditions a kid can die in 10 minutes. In arid and semi-arid areas on the other hand the temperatures in direct sunlight can easily be above 40°C and kill the kid by too much heat. Therefore a clean shady place should be provided for the kidding female.
3. **Water.** At the time of kidding a female will lose a lot of body liquids very quickly. She will also start producing milk and it is essential that kidding females have enough clean drinking water available to restore the liquid balance in the body

Record keeping

For good management a farmer should keep the following simple records (Record sheet for cows can be used - Birth dates - Birth weights - Sire and dam - Milk records - Treatment records - Service dates

Housing for improved management

Zero grazing housing units for goats have been constructed all over the highlands, many of which are very dark and squeezed and giving the goats no space for exercising or browsing as is their nature. Goat pens must be well ventilated, but covered and protected from wind and rain, as goats quickly develop coughs and colds if they are housed in damp or drafty pens. Raised slatted floors are a great advantage in keeping the goats clean and in collection of the manure.

A Good House Means Healthy Goats

A good goat house will make keeping goats easier. It should be rain proof, damp proof, well ventilated if the environment is cold and windy, free from sharp objects that cut the goat, free from direct wind, pest and wild animal proof.

Some of the recommendations for goat houses give very small space requirements for the goats. However goats are naturally very active animals and will be stressed if given too little space to move around. Stressed animals are less resistant to diseases and are less productive than happy healthy animals.

Young kids will want to have space to jump up and down from thing from as early as 2 days old. This seems to be a crucial part of their growth and develops strong healthy legs. In a zero grazing system things like old tyres, large stones etc can be placed in the kid pens for their play and exercise area.

Building Specifications for dairy goats

Houses should be raised at least 1.5 feet (or just below knee height) from the ground. A slatted wooded floor is very important. This has small gaps about half an inch wide (or the width of a side of a match box) between the planks or rafters. Use of local materials means you can use off cut planks, etc. The floor racks made of rafter should be put where the goats feed and sleep, this stops foot rot. When it is wet, keep the house clean and dry.

Feed trough

A goat does not like to graze on the ground like a sheep or cow. Goats like feeding at a knee high on the bush or goat house wall. Goats need to be able to drink fresh water at all times.

The feeding area is built 1 metre (3 feet) above the platform with rafters, off-cuts or timber. Troughs must be easy to clean. Floor of trough can be made of off cuts but must be able to hold hay. Feeding space is 0.15 cm per mature goat.

Water Trough

A water trough is placed 1 foot above the floor in the feeding area. Or a 5 litre can is hanged on the outside of the door to the sleeping room. The door should have a small window or a slot so that goats can have access to water day and night.

Kid pen

Toggenburgs often give birth to twin kids so don't make the pen small. Kid pen should be for at least 6 kids.

Hay barn/store

It is important to store fodder, for use during the dry season. Hay barn are build adjacent to the goat house that is roofed and has a slatted floor to avoid the fodder being rained on.

Mineral trough

Mineral trough should be made where the goats sleep, 1 foot square box is ideal for this purpose. A halved long plastic container nailed to the board, at least 1 foot wide can be useful. Or just as good - hang the salt so that goat has to reach for it.

Milking parlour

Make a milking parlour where needed.

Nutrition - Feeding

Goats are browsers and eat variety of plants/feeds when left to find their own food. This would ensure a balanced diet according to their individual needs. Like all other animals goats need feed for

- Maintenance of body weight and condition
- Production of meat/ milk (There will be very minimal production/ growth rate,

unless the goats have access to more feed than they need for body maintenance)

Goats get bored when fed on the same feed every day. Some time they can be wasteful. They are clean feeders and will not eat feeds which are not fresh and nor will they eat dirty feed e.g. nappier with mud splash from rain. Goats do not like sticky, mouldy, wet or dusty feeds.

Goat feed need the same balanced ingredients as other creatures, only proportions vary according to the stage in the life cycle:

- **Proteins** are needed for growth, production of meat and milk as well as reproduction. Proteins are found in:
 - Legumes such as Lucerne, green beans, cowpeas and other legumes, sweet potato vines, acacia leaves etc
 - Dairy meal, cotton seed cake, sunflower cake, soy bean cake and other oil seed cakes
- **Energy feeds (carbohydrates and fats)** are needed for maintenance of body condition, fattening, all body functions, in general for anything to work. Energy feeds are for example:
 - Grains such as sorghum, maize, millet, barley and wheat
 - Grasses - napier grass, kikuyu grass, or any green grass
 - Hay - dried grasses/weeds etc
- **Fibre** is needed to keep the rumen (stomach) in a healthy working condition. Fibre is found in all plant material. Old dry stems of plants are almost pure fibre. Young green plants have less fibre and more nutrients. Ruminants such as goats can digest a large amount of fibre, but do need supplements, especially if all the available fodder has dried out. If goats get too little fibre they tend to either suffer from bloat or from indigestion (badly functioning stomach).
- **Minerals** are needed for maintaining fertility, building body condition, keeping body functions healthy. Minerals are found in weeds, salt licks, etc.

- **Water** is needed for survival. Lack of water will kill an animal faster than lack of any other food constituent.

How much feed?

The amount of feed needed by goats depend on their size and stage of development. As a general rule of thumb, an animal will need 3,5% of its bodyweight daily in the form of dry matter in feed to satisfy its appetite. An animal will produce nothing and eventually die if its appetite is not satisfied.

A 40 kg goat will thus need 1.35 kg dry matter per day or almost 500 kg in a year. Most FRESH forage contains about 33 % dry matter as an average. The 40 kg animal will then need 4 kg of fresh forage every day or its equivalent in dry forage and feed, which makes about 1500 kg per year.

The main difference between a goat and a cow or a sheep is that the goat has a much bigger rumen in comparison to its body size than the other two animals. The rumen of the goat can be as much as 1/3 of the total body volume. This makes the goat a very efficient converter of rough feeds/ browse, but the process uses up a lot of energy and there is also a need for minerals especially phosphorous. One reason goats prefer browse bushes and trees is that these plants are deep rooted and bring up many more essential minerals from deep inside the soil that the goat needs, than shallow rooted plants do.

In comparison to a cow, a goat

- Produces more milk from the same quantity of nutrients
- Uses less food per kg bodyweight for its body maintenance than a cow
- Uses more food per kg bodyweight for digestion and metabolism than the cow

Milk goat feeding

Feeding the dairy goat mother after kidding

The dairy goat must be fed so it can give enough milk and maintain its own weight. She can be supplemented with at least 200 gm/day of dairy

meal. Ration can be reduced to 100gm/day during the 3rd month after kidding.

The dairy goat gives as much milk as it is given the right food. Some preferred feeds include:

- **Sweet potato vines:** This is liked very much by the goats. It gives tubers for the family to eat and the vines can be fed to the goats. It can be planted beside riverbeds, steep parts of the shamba and on road side edges. Useful in feeding kids whose mothers died early in their life.
- **Napier:** Napier can be planted along river beds, soil terraces or road reserves. Where a farmer has a big shamba, napier is planted near the home to save time for other work while tending to the goats. Good napier needs generous application of manure and needs weeding. Where new fields are being planted mixed cropping with desmodium improves the quality of the fodder. If you plant napier around your maize, it stops maize stalk borer.
- **Fodder trees and legumes:** These have lots of protein. and only a little is needed at a time. The trees and legumes should be planted along the fences and terraces. Leucaena is good in fences. They do not need a lot of work once they are planted. Deslodium: when available should be inter cropped with napier. Calliandra does better in high altitudes (tea zone3) than leuceana. Do not forget many weeds also make good fodder.
- **Maize:** While maize is grown for farmer/s food, there is a lot of fodder which can be used for feeding the goat without stopping the Farmer from a good maize yield. Thinning - all the extra maize seedlings that grow from the same seed hole should be thinned and dried a little before feeding to the goats. Remove extra leaves- this should start with the leaves below the cob as soon as the cob can be seen. Cutting the tops - this should start after the grains have hardened. Stovers - these should have sweeteners (molasses) added or sprinkle common salt after chopping. Broken grains

- these are very nutritious especially after a heavy harvest but should be fed carefully to avoid grain overload.

Feeding the newborn up to 3 months

Newborn kids should be fed on colostrum within 24 hours and should be with the doe and allowed to suckle as much as they need. After one week: - kids should be provided with small quantities of good clean feed e.g. sweet potato vines, tree legume leaves or natural tree leaves. Kids should continue with milk for the first three weeks and thereafter be allowed to feed on milk combined with fresh fodder up to 3-4 month. Provide fodder and water to kids all the time to enable them learn to eat gradually. A poor start will affect the future productivity of that kid when it grows up to adult.

- 0-2 weeks free suckling
- 2-6 weeks suckling day time
- 6-12 weeks suckling twice a day
- 12-13 weeks suckling evening only for 1 week
- 13-14 weeks suckling in the evening, every other day then weaned

Feeding does

Concentrates should be fed to does just before the does are served by the buck Increase feed gradually for 2 months until the doe gives birth. Continue feeding concentrate while she is on milk. The doe needs careful feeding in order to keep its normal weight, be fertile when served so as to get twins (flushing), carry the kid while it is pregnant, provide enough milk to its kids and give extra milk for farmers use.

Feeding the breeding and lactating doe

One month before mating the does should be fed and watered very well to ensure she is in the best of health. If she is fed very well before mating she is more likely to have twins or even triplets. Mineral licks hasten coming on heat Give lots of water at all times.

Feeding during pregnancy

The goat must be fed well with high quality feed during pregnancy. The foetus or kid inside gains its weight during this period. If there are twins or triplets they will need lots of good feed to grow.

Feeding the buck

Feeding should be enough to keep its weight steady but not too fat. A fat buck will not be active. Give more feed two months before the buck goes to serve the does. This will improve the bucks sperm and make it more active. When a buck is being used a lot to serve does, it should be separate from other goats for about 2-3 hrs per day to allow time to eat as well as serve the does. Lots of fresh and clean water needed all the time must be able to lick the mineral at any time.

Feeding sick goats

Feed goats well when ill. Good feeding will give strength. Small, weak, young and sick goats should be fed separately. Follow the best way to feed goats carefully and handle them gently.

Diseases

Health of goats

If animals are well fed, well watered and well managed disease is rarely an every day problem. Goats are generally tough and resilient. Problems come when a farmer begins to expect greater production from his animals by crossing them with exotic breeds. More intensive management is required the more an animal is expected to produce, and this management does not depend on sticking needles in animals. A good goat manager will know the requirements of his/her goats and take great care that their needs are well taken care of.

A healthy goat has

- a smooth shiny coat
- bright eyes
- good appetite
- easy quick movements
- will rest and chew cud regularly
- will pass normal feces and urine (color and consistency can change with change in feeds)
- normal body temperature of 40°C (+- 1°C) higher in the morning than in the evening.
- normal respiration rate of 12-15 breaths per minute (faster in kids).

Diagnosis of sick animals

The early awareness of sickness in animals is important to successful treatment. The longer an animal is sick the more difficult it will be to cure.

Early signs of sickness:

- Stops eating and possibly also drinking
- Becomes dehydrated
- The temperature rises
- Respiration rate increases
- The animal becomes dull and lags behind the others
- The coat becomes rough and loses its shine

Always observe a sick animal before rushing into conclusions. Take its temperature, look for outward signs such as coughing, wounds, diarrhea etc.

Dehydration (lack of liquid in the body) can kill the animal, so the first thing is to provide the animal with shelter and plenty of clean drinking water. Then the sick animal needs energy to fight off the disease. A thin porridge made with any clean grain flour and boiled up with a bit of salt, sugar or honey and cooled is a good supplement to feed a sick goat. Depending on the size of the goat they can be given up to 4 bottles a day at regular intervals. Alternatively make a rehydration solution from 1 liter of boiled water, 4 tablespoons of honey or sugar and 1 teaspoon of salt and give as a drench. A sick goat will respond better to treatment in the company of another goat.

Vaccination: Some diseases can be prevented by vaccination such as Enterotoxemia and tetanus. Pregnant females should be vaccinated 2-3 weeks before birthing so that the immunity can be passed onto the new born kid. When the kid is 6 months old, it should receive a second dose. Also CCPP (contagious caprine pleuropneumonia) is a killer disease which normally occur during the rainy seasons. Therefore it is advisable to vaccinate on an annual basis before the rains start.

Diseases

Pneumonia/CCPP

Potential Mortality: 90% of flock can die

Disease agent: *M. mycoides capri*,

Symptoms: Quick rise in temperature, seriously damaging the lungs. Prevention: vaccinate yearly before the rains. Treatment: If caught in the early stages, a broad spectrum antibiotic treatment can be moderately effective

Heartwater

Mortality rate: Very high especially in young stock

Disease agent: A parasite by the name Cowria ruminantium spread by the bont tick.

Symptoms: laboured breathing, loss of appetite, trembling muscles, nervous twitching of the legs and head, circling movement and stiffness of the neck.

Prevention: Weekly dipping or spraying with recommended acaricides to kill the ticks spreading the disease.

Treatment: Administration of a broad spectrum antibiotic can be effective if disease is caught in early stages.

Orf

Mortality rate: low but growth and productivity affected due to painful feeding.

Symptoms: Lesions on mouth and nose. In severe infections lesions can spread to genitals. Infection in well fed animals usually disappears after 3-4 weeks.

Treatment: No effective cure known

Mastitis (infection of the udder)

Disease agents: Various bacteria associated with poor hygiene. One of the more common ones being *Staphylococcus aureus*. Strains found in goats differ from those found in cows.

Symptoms: The udder becomes hot and painful, and the milk becomes watery and contains clots. Later stages in untreated cases will show hardened udders and blind (unproductive) teats.

Prevention: Keeping goats in clean houses, and using good milking hygiene with clean hands and clean utensils.

Treatment: Special antibiotics applied via the teat. In severe cases the animal should also have a general antibiotic treatment. Females who repeatedly show signs of infection should be culled.

Abortion

Disease agents: Brucellosis, clamydiosis, trypanosomiasis, Q-fever, starvation, heat stress. Early pregnancies.

Remedy: According to disease agent.

Internal parasites

Includes *Haemonchus contortus* (barber pole worm), liverfluke, roundworms

Symptoms: swelling under the jaw, loss of body condition, diarrhea, pale gums, thick nasal discharge, signs of worm presence in faeces.

Prevention and cure: Keep goats in clean houses or bomas to avoid build up of a worm infestation.

Routinely dose adult goats before mating, all kids at weaning and all stock before each rainy season.

External parasites

Such as ticks, fleas, lice and mites, are dealt with by routinely dipping or spraying animals with recommended acaricides. External parasites transfer diseases between animals by sucking blood and should be kept firmly under control.

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Dairy Cattle production

Dairy cattle breeds

The main purpose of breeding of animals is for continuity of life and also the improvement of the existing breeds of animals. It involves the use of superior breeds so that the end products can be of higher quality.

Friesian

Purpose: Milk production

Potential yield: 40-50 kg milk/day Average body size: Large (500-550kg) Description: Black and white short haired coat, short horns

Advantages:

- High milk production potential with low butter fat content of about 3.2%
 - Note: Milk production will depend on level of feeding and other management
 - Suitable for zero grazing and high level management

Disadvantages:

- Heavy feeder
- Susceptible to diseases, susceptible to milk fever
- Susceptible to high temperatures
- - Feed requirements high (90-110Kg fresh forage/day i.e. 3 gunny bags)
- Adequate clean water (min 60 Lts/day, more for heavy yielders)

Airshire

Purpose: Milk production

Description: Body colour is dark brown and white patches

Average body size: Large (average live-weight 450kg)

Advantages:

- High milk production potential (30 Lt/day)
- The cow's milk has moderate butter fat content 4.0%
- Fairly hardy and adaptable to varied AEZs
- Better suited to range management than fresian breed

Disadvantages:

- Feed requirements high (90-110Kg fresh forage/day i.e. 3 gunny bags)
- Adequate clean water (60 Lts/day)

Guernsey

Description: Body colour is brown

Average body size: Medium (average live-weight 400kg)

Advantages:

High milk production potential (25 Lt/day) Milk has moderate butter fat content 4.3% Feed requirements: Moderate (65-85Kg fresh forage/day i.e. 2 gunny bags)

Disadvantages:

Adequate clean water (40 Lts/day)

Jersey

Description: Body colour is grayish-brown, with protruding eyes

Average body size: Small - medium (350 Kg)

Milk production potential is moderate (20 Lt/day), depending on feeding and management regime

Advantages:

- Feed requirements is relatively low (65-85 Kg fresh forage/day i.e. 2 gunny bags)
- Milk has high butter fat content 5.2%
- It is hardy and adaptable to varied AEZs
- Also suitable for cross breeding/ improving local breeds

Disadvantages:

- Susceptible to milk fever and tick borne diseases

Breeding

The farmer may want to achieve the following:

- Increase milk production
- Replace spent stock
- Quality stock for sale
- Adaptability and disease resistance
- Desirable traits which include; butter fat content, longevity, good meat configuration, coloration etc.

Selection of Breeding Stock

Selection of breeding animals is based on:

- Pedigree or parentage information
- Performance records (Estimated breeding values and phenotype)
- Cost of semen from proven bulls
- Available bulls in the area

Then mates are assigned accordingly

Breeding technologies

The following methods are used in breeding:

- Artificial insemination (A. I.)
- Natural mating (proven and healthy bulls where A.I. is not available)

- Multiple ovulation embryo transfer (MOET)

Heat detection and timing

A cow on heat portrays the following signs:

- Restlessness
- Mounting other cows or standing still while being mounted by other cows
- Clear discharge from vulva
- Drop in milk yield
- Bellowing
- Dilated and enlarged vulva

Note: The heat period lasts for about 30 hours starting when a cow will let another mount as per drawing below. Optimal serve time is 8 hours after first heat signs. Time between one heat and the next is 21 days on average.

- A heifer is ready for service at 14-18 months
- Cows resume heat 38th to 42nd day after calving
- It is recommended to serve 60 to 90 days after calving
- Gestation period is 9,5 months
- Calving Interval: Aim at a calf per year per cow

Common causes of infertility

- Retained placenta
- Poor feeding (also mineral deficiency)
- Breeding diseases
- Difficult calving

Calving and calf rearing

Calving Preparation

Dry the cow 2 months to calving. Steam it up by giving 2 to 4 kg of good concentrates per cow per day. Introduce in calf heifers to the dairy unit before calving for them to get used. Isolate cows one week before calving. Normal calving will occur 280 ± 10 days from last service.

Cow calendar

A cow calendar is a very useful tool in estimating calving dates of cows. The cow calendar consist of two separate but connected discs, the lower disc displaying the days of the year and the upper disc the interval between service date, repeat heat

cycles, and calving date. It also shows when a cow should be dried and steamed up (stop milking and start feeding to prepare for normal calving and highest possible milk production). Such calendars can be ordered from CAIS (Central Artificial Insemination Station) Kenya. (Contact: CAIS - Tel: 4181325/6 - Email: info@cais.co.ke)

Calving Signs

The animal will portray the following signs before calving:

- Rigid udder
- Clear discharge of mucus from the enlarged vulva
- Loss of appetite and restlessness
- Relaxation of ligaments on both sides of tail

Precautions during calving

The following precautions should be observed before calving to ensure safety of the mother and its calf:

- Pay special attention to calving heifers as they are likely to have problems
- Disinfect hind quarters before calving
- Ensure that after the calf is born it is licked by the dam and is free of mucus at the nostrils, mouth and eyes
- Naval cord should be cut and tied then disinfected with iodine
- The newborn calf should be allowed to suckle the mother the first 24 hours to get colostrums before isolating it
- Placenta (afterbirth) should come out within 12 hours after calving
- A veterinary doctor should be called in case of a difficult calving or retained placenta

Calf feeding

A successful livestock owner knows that it really pays to take very good care of the young stock. The bull calves can be sold for meat and the heifer calves are the future cows and production animals. Any losses means future income will be reduced.

All newly born calves should be fed colostrums within 24 hours after birth to improve their

immunity. Colostrum (the first milk the dam produces after calving) is a very concentrated food and disease prevention medicine for young calves and they must have as much as possible within 24 hours of being born. Without colostrum a calf will be malnourished, grow poorly and prone to diseases throughout its life. Mostly such calves do not survive long. After the first 24 hours the stomach of the calf closes for the antibodies contained in the colostrums and only takes up the nutrients. The colostrums gradually becomes thinner and more like normal milk until after about a week it can be mixed with other milk.

- Where buckets are used for feeding, clean them thoroughly before feeding calves to avoid infections.
- Milk should be fed at body temperature (37°C) i.e. immediately after milking.
- At 2-3 weeks of age a calf should be fed 5 Lts of milk /day.
- At 4-7 weeks feed 6 Lts/day (late weaning) or 4 Lts/day plus 0.25-0.75 Kg/day of early weaning pellets (early weaning)
- If a farmer has to feed milk replacers then it is absolutely necessary to follow manufacturers' instructions for reconstitution.
- Calves should be provided with good quality hay and fresh forage by the 3rd week to enable the calf to start developing its rumen. Calves should be left to graze where good pastures are available. The calves should have access to unlimited supply of water and minerals. Calves should be sheltered in a clean and dry environment

Calf weaning

Weaning is done to enable the dam to return on heat and is recommended at between 3-4 months of age or depending on the weather conditions. Calves should be weaned when there is adequate pasture and is done by separating calves from the dams.

- Calves are weaned at 12 weeks of age for early weaning or at 16 weeks for late weaning
- To wean, you provide adequate amount of solid feed e.g. concentrates, hay and green

forages. To be weaned the calf should have increased its girth (LWt) by 2 ½ times the birth weight e.g. if a calf was born at 35 kg LWt. then it should be weaned at about 90kg LWt

- Weaning method is by reducing liquid diet gradually over a period of 10 days. Towards the end of the weaning period the calf may be given only one liquid meal per day
- For beef breeds calves are left with their dams as long as practically possible. This gives the highest growth rate.

Calf Housing

Housing requirements:

The calves must be duly protected from cold, rain and too hot sun especially when very young. They must also be kept clean and free from ticks and fleas. Use gentle insecticides like pyrethrum on very young calves. The tender skin can absorb the more poisonous sprays often used on mature animals.

Calf pen should be 1.5 m long by 1.2 m wide (5x4 ft). There are three common types of calf pens:

- Permanent calf pen with slatted floor: - It should be 0.6m above the ground. Slats of 2 x 2 timber separated at 1 inch apart and connected by 3 x 2 timber.
- Permanent calf pens with cemented floor: these are cubicles, stone built at 1.5m L x 1.2 m W, sloped for free drainage
- Mobile or portable calf pens: Roofed and kept outside. Slats are not necessary for this type as it is moved in pasture from point to point every 2 days

Calf pens should be provided with water in a bucket, feed in feed trough and salt lick. Good hygiene must be kept by properly cleaning and disinfecting the pen before restocking. Dry straw as beddings is to be provided on cemented floor daily and ventilation and sunlight if the pens are in the house be allowed.

Other Calf Management Practices

Disbudding

Disbudding is done 2 to 3 months of age.

Use disbudding iron or caustic stick.

To disbud, we heat the iron until red hot. Clip off the hair around horn area. Place the heated iron end over the bud at intervals of 5 to 10 seconds, each time firmly but not hard pressure. We stop heating when the colour of the bottom of the bud turns deep copper and finally apply disinfectant.

Removal of extra teats

If a heifer has more than 4 teats, remove the extra teat. This should be 2 to 3 weeks of age. We cut the extra teat carefully with a sharp pair of scissors and disinfect the scar with iodine.

Castration and calf marking

Castration is done 2 to 4 weeks of age (for dairy) and 6 to 9 months (for dual breeds). We use elastrator, a burdizzo or open method.

All calves should be marked after birth particularly when they are many. This is very necessary for identification and record keeping. Ear tagging, tattooing and branding can be used.

Castration

Castration is done to reduce inbreeding and to achieve well-distributed fat in beef animals. It is the easiest to do it during the first week by applying castration rubber bands to males not meant for breeding.

De-worming

De-worming is the use of medicine to kill worms and other internal parasites through application of the medicine through the mouth. Worms compete for food with the calf leading to retarded growth. De-worming in calves is done as soon as they start grazing and thereafter every 3 months.

Disease control

Dipping or spraying using recommended acaricides does control of ticks and external parasites. This is done to avoid transmission of diseases to the animals. Spraying and dipping should be done weekly.

Vaccination

This is application of protective medicine mainly by injection to control diseases. For calves, vaccination against Brucellosis, Anthrax and

Blackquarter is essential. For Brucellosis, it is done at 3-8 months of age while Anthrax and Blackquarter is vaccinated at 6 months of age. Adult to undergo routine vaccinations as recommended against major diseases such as FMD, Brucellosis, LSD, CBPP etc.

Common calf management challenges

Calf scours

Causes: Poor nutrition and feeding e.g. dirty milk, dirty buckets, overfeeding etc.
Signs: Calf scours (whitish diarrhoea), soiled tail, loss of appetite, high temperatures and dehydration.

Control: Reduce or completely withdraw milk for two to three meals. If the above does not work withdraw milk 2-3 meals and then replace it with warm water mixed with ½ tablespoon of baking powder plus two tablespoons of common salt and 110g of glucose (mixed in 4.5 litres warm water). If disease is persistent consult veterinarian. If no veterinarian is available there may be sulphamide tablets available from the nearest chemist designed for scouring calves. Use only as directed.

Calf Pneumonia

Causes: The disease occurs if the calf is exposed to sudden chilly conditions (draughty quarters) or poor ventilation.

Signs: Watery discharge from nose and eyes, shallow and rapid breathing, coughing, loss of appetite and high temperatures.

Control: House all calves at least for the first 6 weeks; Avoid draughts; Treatment with suitable drugs. If disease is persistent consult veterinarian.

Milking

Good milk handling practices

Milk is the main product from a dairy enterprise, produced basically as food for human consumption. Milk is a very good media for bacterial and other micro-organisms development. Clean milk production results in milk that:

- Is safe for human consumption and free from disease causing micro-organisms
- Has a high keeping quality
- Has a high commercial value

- Can be transported over long distances
- Is a high quality base for processing, resulting in high quality products

Pre-milking

Restrain the cow. Wash udder, teats and flank of the animal with clean water preferably add a disinfectant. Wipe with a clean cloth (A piece per cow). Apply suitable milking salve on each teat. Check for mastitis with a strip cup or any other method. Dispose fore-milk. Isolate sick animals and milk them last (Their milk should not be mixed with good milk).

Milking

- Do not excite the animals
- Regularize milking intervals
- Squeeze the teat and do not pull.
- Avoid incomplete milking
- Milking should be complete within 8-10 minutes
- Use a teat dip after milking

Milk Handling

- Use a clean white muslin cloth for filtering immediately after milking
- Disinfect, wash and dry the filter cloth after use
- Weigh and record milk per cow
- Store in cool and clean place
- Room used to store milk be without other materials such as chemicals
- Deliver milk to the market as soon as possible

Utensils

Use seamless containers preferably aluminium or stainless steel

- Rinse excess milk with cold and clean water
- Scrub with a brush using hot water mixed with a soap or detergent
- Rinse with cold water and place the utensils to dry on a rack
- Store utensils in a safe, clean, well ventilated place

Milker's Hygiene

- Be healthy and clean

- Maintain short finger nails and hair cut (ladies can cover their heads when milking as guard to falling hair)
- Avoid smoking during milking time
- Wear clean white overall and gumboots

Milking Environment

- Locate shed away from odours
- The shed can be permanent or movable
- Where possible provide a cement floor for ease of cleaning
- Clean shed after every milking
- Water should drain easily and away from the shed
- Provide a clean feed trough, water trough and protected store
- Provide clean water

Nutrition - Feeds and feeding

Scientific basis for cow feeding

Carefully controlled feeding experiments have enabled scientists to state the requirements of farm animals in two definite terms:

1. The maintenance requirement which can be defined as the amount of fodder required to sustain life and health without loss of body weight.
2. The production requirement which are the fodder needs for:
 - Increase in live weight, either as growth in young animals or increasing bodily condition in mature animals
 - The production of milk in the lactating animal
 - The performance of work in the case of oxen, donkeys or other beast of burden

Therefore only if animals are fed more feed than they need for survival, they will produce milk/ gain weight in case of beef production.

It also follows that for grade milk cows the more and better quality feed (fed on top of the survival rations) the more milk will they give until their maximum potential is reached, if all other management practices are in order.

From 1975 the British Ministry of Agriculture has used a system for calculating feed needs of different breeds called Metabolisable Energy as a basis for formulating rations on the farm.

Metabolisable energy basically means that part of the feed which the animal is able to utilize. The basis unit of energy in the ME system is the megajoule (MJ). All foods contain energy, but it is not all available to the animal.

Parts of all feed is lost in the faeces, this part is described as indigestible. Other losses of energy occur in the production of methane, the urine of the animal and the loss of body heat. The energy remaining after all this is called the Metabolizable energy or ME.

For 1 kg of live weight loss there is a contribution of 28 MJ of dietary ME, and for gain of 1 kg live weight, the ration must supply an extra allowance of 34 MJ.

In early lactation due to stress of calving, the appetite is known to be reduced by probably 2-3 kg per day less than the expected intake. Once the energy, protein and dry matter intake of the animal is known, then the next step is to assess the foodstuffs available on the farm and match the food available to the inputs required.

Dry matter intake

A cow's appetite in terms of dry matter intake is related to bodyweight and also to the amount of milk being given. The amount of feed also depends on the palatability of the feed being offered as well as on the speed at which it passes through the animal. Fresh green grass for example passes through the animal so quickly the animal cannot extract enough energy to satisfy its needs. This is why animals take some time to gain weight at the beginning of the rainy season. On a high fibre diet, the feed passes through the stomach much slower. The high fibre often means the nutrients are indigestible and once again the animal obtains less than her requirements of energy and protein.

Roughages

Roughages includes green forages i.e. Napier grass, Lucerne, sweet potato vines, hay, silage and fodder trees, pastures and crop residues.

All fodders should be chopped and fed in feeding troughs to avoid feed wastage.

Pastures are fed through controlled/free grazing.

Crop residues and poor quality hay can be fed by first soaking in water or molasses.

- An average adult animal requires 65 -110 kg of wet forage per day for maintenance feed depending on breed (see breed description) or an equivalent amount of hay/silage.
- Good quality forage fed in excess to maintenance feed can yield 7-10 Lts of milk/cow/day without supplementation and 15-20 liters if legumes are a good part of this feed

Concentrates

- These include dairy cubes, dairy meals, maize germ, bran (wheat, rice or maize), cotton seed cake sunflower cake, Soya bean cake etc. Also dried and crushed legumes can be used as concentrates to mix with other feeds.
- Concentrates should have 15-18% crude protein
- 2-4 kg/day/cow are given during steaming up
- A farmer should give 1 Kg of concentrate for every 1.5 Lt of milk above the first 8 Ltrs

Minerals

Dairy cows should have appropriate levels of Ca, P, Mg and other trace elements. They are available in granule & solid block. Feeding should be adlib / (80-110 g/cow/day).

Water

Dairy cows and calves should be provided with clean drinking water at all times. Farm animals will consume from 3-8 times more water as compared to dry matter, and will die from lack of water quicker than from lack of any other nutrient. Water is required for all body functions, and there is a constant loss of water from the body through milk, urine, faeces, perspiration (sweating) and breathing. The higher the production and the hotter the climate the more water is required.

Ration

- Dairy cattle ration should contain 70% energy source, 30% protein source and required minerals (such as: 35% wheat bran + 35% maize + 30% cotton seed cake + 1% minerals).
- Maintain CP (crude protein) at 15-18% for optimal production
- Total mixed ration (TMR) can be made depending on specific farm requirement (Consult: Livestock nutritionist)

Calculating feed requirements for a dry season:

When calculating how much feed to store for the animals for the dry season also young stock need to be counted. If each cow in average has one calf per year and both survive, young stock can be calculated as average half the amount of the mature animal.

Zero grazing

General Information

- Zero grazing means growing or acquiring high quality feeds and feeding animals confined in a structure
- Saves the animal the energy used in walking in search of feed leading to higher production
- It is however, labour and capital intensive
- Prices of milk must be good enough to meet the costs of production and make profit

Feeding

- High yielding fodder e.g. Napier grass and lucerne should be planted near the zero grazing unit
- Fodder conservation should be done where possible e.g. silage or hay
- All forage should be chopped before feeding and feed troughs should be used
- Feed troughs should be sizable to accommodate 65-110 kg of chopped feed material per day
- Supplement based on milk yield
- Clean water and minerals adlibitum

Housing

- Construct units according to approved plans obtained from livestock extension officer

- Such plans gives dimensional specifications and materials, for cubicles, feed troughs, water troughs, calf pens, milking parlor, feed store, floor slope, etc.
- Use of durable cheaply available materials is recommended
- A cemented floor is preferred because of the constant washing required

House hygiene

- Remove dung daily
- Clean floor daily
- Provide clean water
- Ensure cubicles and calf pens are dry

Semi zero grazing

- Animals are grazed in the morning and stall fed in the evenings
- Commonly practiced in medium size farms

Diseases

Types of Diseases

Diseases in cattle are categorized into two:

1. Notifiable diseases

Name	Type of vaccination	Remarks
Lumpy Skin Disease (LSD)	Once a year	-
Contagious Bovine Pleuro pneumonia (CBPP)	Once a year	-
Rinderpest	Every 6 months	-
Foot and Mouth Disease (FMD)	Every 6 months	-
Rift Valley Fever	Yearly	Also affects human beings
Anthrax and Blackquarter	Every 9 months	Also affects human beings
Brucellosis	Once in a lifetime(to calves only)	Also affects human beings
Malignant catarrhal fever	No vaccination	Avoid contact with wildebeest
East Coast Fever (ECF)	No vaccination	Treatable
Trypanosomiasis	No vaccination	Protective medicine available

Note: All notifiable diseases require imposition of quarantine.

2. Non- notifiable diseases

Milk Fever

Common in high yielding lactating cows just after calving. Milk fever can kill an otherwise healthy cow in less than 24 hours if not successfully managed.

Causes: Nutritional disease/disorder associated deficiency of Calcium. Friesian and jersey cows are highly susceptible.

Symptoms: Cow staggers on moving; cow feels hot to the touch (fever); Cow will lie down on its side with legs thrust out and head turned back.

Prevention

- If the cow is left with its calf for the first 3 days after calving and not milked by people during this time, many cases of milk fever can be avoided. Besides, the first week's milk is not suited for mixing with other milk for sale.
- A handful of agricultural lime mixed with the first feed given after birth will prevent most cases of milk fever.

Treatment

If discovered early enough, a handful of lime in a bottle of water and fed to the cow may be sufficient for the cow to recover. For late discovered cases of milk fever (when the cow is no longer able to drink) only the use of calcium formulations administered right into the bloodstream by a veterinarian can save the animal (consult veterinarian).

Parasites

Ecto-parasites are mainly ticks, fleas, and flies.

Prevention and control:

- Regular dipping or spraying with effective acaricides and insecticides.

Endo-parasites include roundworms, flatworms, liver flukes, etc

Prevention and control

- Administer anthelmintics at recommended rates every 3 months (vet advice is necessary here).

Tick borne diseases

Cause: These are diseases transmitted by ticks. They include ECF, Heart-water, anaplasmosis and babesiosis (red water).

Prevention:

- Regular dipping or spraying with approved and effective acaricides.
- Vaccinate against ECF. For treatment consult a veterinarian

Mastitis

Mastitis is one of the most common challenges to milk production in East Africa, and is not even always recognised as a disease.. Mastitis is the infection of the teat milk canal spreading into the udder, and making the milk unfit for consumption. The main causes are bacteria, but cases of fungal mastitis are also known. The entry of the bacteria into the teats can come via the milk canal from dirty hands, or through small scratches caused by rough milking, tick bites, encounters with thorns etc. It is therefore very important to always clean the teats and the hands milking them very well before milking, and if any scratches are seen to disinfect the teats immediately after milking.

Causes: Poor milking hygiene/technique (stripping); Incomplete milking; Muddy environment.

Prevention

- Clean milking environment
- Use of strip cup - this will show early infections as small nodules of coagulated milk will show in positive cases
- Teat dipping after milking in antiseptic
- Milk infected quarters/cows last
- Proper milking - do not over pull the teats
- Proper drying of milking cows (dry cow therapy)
- Vaccinate cows right after giving birth against mastitis (much cheaper than treatment). One vaccination will protect the cow for a full lactation period against most mastitis causing bacteria, and yields will not be lost due to mastitis.

Treatment

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- Use of recommended intramammary antibiotics
 - If persistent consult veterinarian
- Pneumonia, Foot and Mouth Disease (FMD), Hoof diseases, Rift Valley Fever

Further important cattle diseases include ECF (East Coast Fever), Anaplasmosis, Babesiosis,

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CHAPTER 14: POST HARVEST MANAGEMENT AND VALUE ADDITION

1. Introduction

Reasons for processing of fruits and vegetables

1. Reduce bulk and perishability leading to ease in transportation and marketing.
2. Add value to the fruits and vegetables thus improve family income.
3. Reduce post-harvest losses and vegetables throughout the year.
4. Support local cottage industries through creating demand for equipments required in processing

Basic hygiene requirements during processing.

Food products are prone to contamination, which can have serious effects on consumers.

High standards of hygiene must therefore be observed during preparation, processing, packaging and storage.

Some of the basic requirements are: - Cleanliness, spacious rooms and personal hygiene (short nails, no cutex etc)

Value-added activities can provide a supplement to a farm's other agricultural enterprises. The addition of value can result from the application of the farmer's own time, management, skills, and resources to make products with less capital expenditures and purchased inputs, as well as from the sale of

products of higher intrinsic value for consumers who are willing to pay more for quality. To have market power, value-added agriculture must create incentives for resource stewardship and reward sustainable production systems.

Food processing aims to make food more digestible, nutritious and extend the shelf-life. Due to the seasonal variations high levels of wastage or shortages can arise if adequate measures are not taken to preserve and store the foods.

Food processing covers all the processes that food items go through from the farm to the time it arrives on the consumer's plate. It includes basic cleaning, grading and packaging as in case of fruits and vegetables and also alteration of the raw material to a stage just before the final preparation. Value addition processes to make ready-to eat food like bakery products, instant foods, flavored and health drinks, etc. is also included in this definition.

Food processing benefits all the sections of the society. It helps the:

- Farmers - get higher yield, better revenues and lower the risks drastically,
- Consumers - have access to a greater variety, better prices and new products,

- Economy - gets benefitted with new business opportunities for the entrepreneurs and the work force gets employment.

Agro processing has a tremendous potential for increasing income through value addition and increasing shelf life and access to food security through the establishment of small scale agro processing businesses and rural agro based industries.

Six (6) Key Strategies for Adding Value

- Changing physical state of products
- Producing enhanced value products
- Differentiating products
- Bundling products
- Producing more products that improve efficiency up the supply chain

Importance of post harvest management

1. Proper handling, packaging, transportation and storage reduces the post harvest losses of fruit and vegetables.
2. Processing and preservation technology helps to save excess fruit and vegetable during the glut season (off season).
3. The technology has become a necessity to improve the food safety and strengthen nations food security.
4. The technology helps to boost export of agricultural commodities in the form of preserved and value added products.

2. Principles and methods of preservation of fruits and vegetables

a. Preservation:

Preservation means just protect the foods against the spoilage, but scientifically it may be defined as a science which deals with the process for prevention of decay or spoilage of the food is called preservation.

In other words, just controlling the physical, chemical or microbial changes in the foods is called preservation.

- Physical changes : Colour, flavour, texture and taste etc.
- Chemical changes: Carbohydrate, fats, proteins, vitamins and minerals.
- Microbial changes: Mould, yeasts and bacteria

Why do we preserve the food?

- To supply to increase the shelf life of the food for increasing the supply.
- To make the seasonal fruits available throughout the year.
- To add the variety to the diet.
- To save time by reducing preparation, time and energy by fire.
- To stabilize the prices of the food in the market.
- To improve the health of the population.

Principles of Preservation: There are three main principles :

- A. Prevention / delay the microbial decomposition of the food.
- B. Prevention / delay the shelf decomposition of the food.
- C. Prevention of damage by insects, animals, mechanical causes etc.

A. Prevention / delay the microbial decomposition of the food :

1. By Keeping out the micro organisms (Asepsis)
2. By Removal of micro organisms (Filtration)
3. By Hindering the growth and activity of micro organisms (Anaerobic condition)
4. By Killing the micro organisms (Exposing at high temperature)

Asepsis- It means preventing the entry of micro organisms by maintaining of general cleanliness, while picking, grading, packing and transporting of fruits and vegetables, increase their keeping quality and the product prepared from them will be superior quality

B. Prevention/delay the shelf decomposition:

- (i) By destruction or inactivate the enzyme (Blanching.)
- (ii) Prevention / delay the non-enzymatic chemical reactions – Antioxident

Blanching:

- It is a primary treatment which have to soften the tissues to facilitate packaging.
- To preserve the original colour and flavour
- To destroy the certain enzyme which are undersirable
- Elimination of the air
- Mostly for vegetables
- Remove micro-organisms
- Remove astringent taste and toxins

Methods of preservation of fruit and vegetable:

There are two main basic methods:

- a. Bacteriostatic methods
- b. Bactericidal methods

A. Bacteriostatic Methods –

- Drying of foods
- Use of chemical preservatives
- Use of food additive
- Use of low temperature

B. Bactericidal Methods –

- Pasteurization
- Cooking
- Canning
- Irradiation

DRYING OF FOODS:

Drying is just removal of moisture from the food to a certain level at which micro organisms can not grow is called drying, it can be done by two methods:

i. Application of Heat:

- a) Sun Drying: Sun drying is the method in which food is directly exposed to sunlight. It is generally done in the places where plenty sunshine is available for long period e.g. Rajasthan. The dried product in this method is inferior in quality.
- b) Mechanical drying: This is a method of drying where application of heat is applied

by a mechanical dryer under the controlled conditions of temperature, humidity and air flow.

- c) Vacuum drying: the temperature of the food and the rate of water removal are controlled by regulating the degree of vacuum and intensity of heat input.
- d) Freeze drying: In this method, the food is dried by sublimation process, i.e., just converting the food into ice without passing through the liquid form of water by means of vacuum plus heat applied in the drying chamber. In this method, product first frozen then water is removed by vacuum and application of heat which occurs simultaneously in same chamber.

ii. Binding the Moisture:

- a) Use of Sugar: The use of high concentration of sugar bind up the moisture and make the food have a certain level of moisture at which micro organisms are not able to grow.
- b) Use of Salt: The concentration of salt causes the high osmotic pressure and tie up the moisture which inhibit the growth of micro organisms. It dehydrate the food by drying out and tie up moisture as it dehydrate the micro organisms cells. Salt reduces the solubility of O^2 in the food by reducing the moisture. It interfere with the action of proteolytic enzyme. The effectness of NaCl is varied with the concentration of salt and temperature.

Pre and post harvest factors affecting quality in post harvest shelf life of fruits and vegetables

The quality and condition of fresh produce cannot be improved after harvest. The adoption of good practices is advisable before and after harvest of fruit and vegetables.

Pre-harvest factors

- Cultivar and root stock genotype: It plays an important role in determining the taste, quality, yield, nutrient composition and post harvest life of fruit and vegetable.
- Water supply (irrigation)

- Excess rain or irrigation, leads to brittle and easy damage in leafy vegetables and to reduced tendency to decay.
- Lack of rain or irrigation leads to low juice content and thick skin in citrus fruit.
- Dry condition followed by rain or irrigation leads to growth cracks in tomato or
- secondary growth in potatoes.
- Soil fertility and use of fertilizers

Lack of nutrients in the soil can seriously affect the fresh produce at harvest. Too much of fertilizer can affect the development of post harvest condition of some produce.

- Mineral nutrition

Deficiencies or excess or imbalance of various nutrients are known to result in disorders that can limit the storage life of many fruit and vegetables.

- Foliar nutrient spray

Ca is often considered to be the most important mineral element in determining fruit quality, especially in apples and pears where it has been demonstrated to reduce metabolic disorders, maintain firmness and reduce decay.

- Cultivation practices:

Good management practices is very much important in achieving good yields and quality of fresh produce (weed control, crop hygiene, pesticides and herbicides, growth regulating chemicals).

Post harvest factors

- Perishability and produce losses:

All fruits and vegetables and root crops are living plant parts containing in 65-95% water and they continue their living processes after harvest. Their post harvest life depends on their stored food and water loss.

- Physiological deterioration

High temperature, low atmospheric humidity and physical injury maximize the rate of natural deterioration.

- Mechanical damage (Physical injury)

Careless handling of fresh produce causes internal injury, which results in abnormal physiological damage.

- Pest and Diseases

Fresh produce can become infected before or after harvest by diseases widespread in the air, soil and water. Pest damage also play major role.

3. Food processing and preservation.

FRUIT PROCESSING

Fruit juice making

Materials/ingredients

- Fresh fruits- e.g. orange, pawpaw, pineapple, passion, mango etc.
- Knives
- Blender (juice extractor)
- Plastic containers and sieves

Procedure

- Select ripe fruits
- Wash the fruits thoroughly with clean water.
- Cut the fruit into two and remove the seeds.
- Pulping/juice extraction -Juice can be extracted in a number of ways:
 - ✓ by pressing
 - ✓ By pulping, using purpose-made pulpers, blenders, or a pestle and mortar.
- Straining- this is aimed at producing clear juice free from particles (clear juice). To achieve this, the extracted juice must be strained using a muslin cloth bag-Pass the juice pulp through the muslin cloth bag.
- Put in some lemon juice.
- For 1 cup of juice pulp, add 1 cup of water and 30gms sugar (to taste).(water and sugar should be boiled to make a syrup before adding to fruit juice)
- Sieve and serve or pack.

Fruit Jams and Jellies

E.g. pawpaw jam, tomato jam and guava etc.

This is a solid gel made from fruit pulp or juice, sugar, and pectin. It can be made from a single fruit or from a combination, but in either case the fruit content should be at least 40 per cent. In mixed-fruit jams, the first-named fruit should be at least 50 per cent of the total fruit added (based on European legislation). The total sugar content of jam should not be less than 68 per cent to prevent mould growth after opening the jar.

Fruit jellies are crystal-clear jams, produced using filtered juice instead of fruit pulp

Materials

- a) Ripe fruits
- b) Plastic Containers, sieve etc
- c) Sulfur
- d) fire

Procedure

- Take the ripe fruits eg pawpaw, tomato etc, etc
- Wash them thoroughly
- Cut them in two and remove the seeds (where applicable)
- Pulping/juice extraction -Juice can be extracted in a number of ways:
 - ✓ by pressing
 - ✓ by pulping, using purpose-made pulpers, blenders, or a pestle and mortar.
- Straining- The starting material for the production of jams is pulped fruit. To achieve this, the extracted juice must be strained using a muslin cloth bag. Additionally, sugar syrups should be strained in order to remove any unwanted material.
- Measure the pulp and water (for 1 cup of pulp, add ½ cup of water)
- Boiling can be carried out in a stainless steel or enameled metal pot. If pans made from other materials are used there is the possibility that the fruit acids will react with the aluminum pan and cause 'off' Flavours- cook for about 20 minutes with low heat
- Add in sugar (for 1 cup of pulp, add 1 cup sugar)
- Squeeze some lemon juice in a plastic container and add it to the cooking mixture, cook briskly or in low heat until it settles.
- Remove from the mixture from fire and let it cool.

- Put in sterilized bottles and cork.(sterilize by boiling the bottle and cook in hot water)
- Put in a cool dry place.

Fruit Marmalades

These are produced mainly from clear citrus juices and have fine shreds of peel suspended in the gel. Commonly-used fruits include limes, grapefruits, lemons and oranges. Ginger may be used alone or in combination with the citrus fruit. The fruit content should not be less than 20 per cent citrus fruit, and the sugar content is similar to jam.

Marmalade is a fruit preserve made from the juice and peel of citrus fruits boiled with sugar and water. It can be produced from lemons, limes, grapefruits, sweet oranges and other citrus fruits, or any combination thereof.

Tomato sauce

Ingredients for 1 litre of tomato sauce

1. Water---750ml
2. Sugar---120gm(12 tablespoons)
3. Gum Arabic ---0.5g
4. Tomato Paste----70gm
5. Salt--- 35gm
6. Onions--- ¼ Bulb-/ or 2gms
7. Sodium Benzoate 0.5g
8. Tomato essence -2 mls
9. Corn Starch 50 gms
10. Acetic Acid 6ml
11. Ascorbic Acid -0.5gm
12. Food Color (Red) -1gm

Procedure

1. Mix the corn starch with water
2. Put tomato paste(from fresh tomatoes or packed) and mix
3. Put onion powder/garlic and mix
4. Sieve the mixture
5. Mix sugar and gum Arabic (dry) then add the mixture to the sieved extract
6. Add salt to the mixture
7. Boil (on moderate fire) as you stir until it is thicker to the desired texture(paste)
8. Add-
 - Acetic acid
 - ascorbic acid

- Tomato essence
- Food colour
- Sodium benzoate (premix sodium benzoate with some little water and add it) mix well

Once all this is done its ready for use. If properly packed and stored it has a shelf life of 8 months.

Juice making

Commonly used fruits includes:-Pawpaw, Mangoes, Passion fruits, Lemons, Oranges

- **Pawpaw juice**

Ingredients: Pawpaw fruits, lemon, sugar and water

Method

- Select, wash and peel the pawpaw.
- Remove seed and pound into pulp.
- Sieve the pulp.

1 cup pawpaw pulp, mix with 1 cup water and 4 table spoons of lemon juice.

For every 2 cups of mixture, add 1 cup of sugar and put the mixture on a low fire while stirring to dissolve the sugar. Do not boil.

Pour the juice in clean hot sterilized bottles and cover.

Juice Processing

This involves boiling the bottled juice in a sufuria of boiling water with a cloth at the bottom to make a “false bottom”. This set up is called a water bath. The bottled juice stays in the boiling water for 15 – 20 minutes in order to kill any germs since juices are not boiled during preparation.

Avocado milk shake

Ingredients

- 1 large (or 2) small ripe avocado
- 1 litre milk
- 8 table spoon lemon juice and Sugar to taste

Method

- Peel and chop the avocado into small pieces
- Blend or mash it and pass through a sieve
- Add sugar and lemon juice and mix well
- Stir in the milk to the consistency you desire
- Pour into a jug or bottle and serve it best chilled

Banana Milk Shake

Ingredients

- ½ glass milk (per person)
- Small ripe banana
- Ice cubes

Procedure

- Mash and sieve the banana
- Put the banana pulp with milk and ice cream in a container
- Shake vigorously
- Serve at once (best served when chilled)

NB: In orange milk shake, done as above but add sugar to the juice.

Banana chips

Ingredients

10-12 unripe bananas, knife, salt and oil / cooking fats

Procedure

- Peel the bananas
- Slice them into small pieces
- Heat the oil / fats
- Dip the banana slice into the boiling oil for 15 minutes
- Let them cool and serve or pack for sale.

DAIRY PRODUCTS

Yoghurt

Milk fermentation is the process which involves the breakdown of lactose in milk into lactic acid by lactic acid bacteria.

Ingredients- for 1 litre of yoghurt

- Milk – 1.2 litres

- Starter culture- 0.25gms
- Flavours (emulsion/essence)- e.g. strawberry, vanilla, banana etc.- 1 ml
- Sugar -3 table spoons (or less to taste)
- Food Colour (raspberry/strawberry) - 1gm. (not necessary when using ready yoghurt as culture)
- Incubator or fireless cooker
- Thermometer and lactometer

Procedure

- a. Start with good quality fresh milk- it is important to get good quality milk which is free from- added water, colostrum, mastitis, high acidity(not sour). This allows milk to reach the proper pasteurization temperature and less interference with lactic acid bacteria which is introduced for proper coagulation (change from liquid to fermented milk).
- b. Pasteurization- pasteurization is to sterilize the milk by heating or radiation to destroy harmful pathogenic. Microorganisms and improve the viscosity taste of milk. Heat or pasteurize the milk to 80 -85°C for 20- 30 minutes to denature and coagulate the milk protein. This also helps to reduce the amount of water in milk, it also helps in sterilizing.
- c. Remove the milk from fire while sieving with a clean fabric to remove any cream and other particles
- d. Cooling -Let the milk cool without any disturbances to a temp of 40-50 °C (inoculation temperature) – keep removing the cream that forms on top as it cool. This is the required temperature at which the yoghurt starter culture or bacteria will produce the required acidic condition necessary to coagulate the milk and give the desirable end product of between 0.8-0.9% lactic acid)
- e. Premix the 0.25 gm. of starter culture with little milk
- f. Inoculation -Inoculate by adding the starter culture mixture to the milk, and then pour the inoculated milk in plastic or stainless steel containers and cork.
- g. Incubation - Incubate maintaining a temperature of (40-42°C) for 8- 12 hours or

overnight (- put in a fireless basket in order to maintain the 40- 42 °C for 8-12 hrs.)

- h. After the incubation period, add sugar-(3 tablespoons per litre of milk or quantity sufficient), add flavors- (1 tablespoon per litre). Add food colour -(1gm per litre or quantity sufficient)
- i. Pack in plastic containers and store at appropriate cool temperature or serve.

Shelf life - 72hrs @ room temp or 14 days@ 0-4°C (in fridge)

NB old yoghurt can be used to make yoghurt as a starter. I.e. 1 liter of yoghurt to be put in 10 litres of milk

Butter making Procedure

- Take the cream removed from cooled milk (i.e. 1-2kgs)
- Whip until all the milk is out- mix until all the fat separates with water
- Wash the cream and make sure that the last water is clean or wash the cream until no trace of milk is seen
- Add a pinch of salt i.e. 1kg of butter add 2% of salt
- Store in cool dry place

Ghee making Procedure

- Take the cream and whip it until all the milk is out
- Wash the cream and make sure that the last water is clean
- Take a sufuria, put in the prepared cream
- Let it boil with moderate fire until all the impurities settle
- Let it cool, pack and store in a cool place

SOYA PROCESSING

Although soybeans are highly nutritious, incorrect preparation of the beans can result in

- Products which do not taste good

- The body failing to make use of the nutrients

To get rid of these two problems, it is important to follow these basic practices:

- Selection of soybeans- damaged seed result in production of bad smell in the products; they are more prone to giving the off beanie flavour and so should be discarded.
- Cleaning and blanching the seed- clean soybeans of unwanted material such as stones, straw, grass, seed, and dust. Bad smell develops when the seed is split; damaged or cracked beans come in contact with cold water. Therefore add soybeans into boiling water and boil for 25-30 minutes. Do not wash the seed in cold water. The anti-nutritional factor, Trypsin Inhibitor (TI) is found in soybeans in large quantities. TI affects the digestion of the protein in the body. TI is destroyed with heat treatment like boiling and roasting. The beanie flavour of soya beans is caused by the reaction of lipoxygenase enzyme and fat in the presence of cold water. The enzyme lipoxygenase is destroyed by moist heat(boiling for 25 to 30 min)
- Soya beans can be processed into many products. These can thereafter be used in many dishes. Some of the common products are:

Soya flour

- After selection, boil water and drop in the soybeans as the water continues to boil for 30 minutes
 - Remove from fire and drain
 - Dry for 3- 4 days according to the weather then mill
 - Store the flour in a covered and labeled container
- Generally the soy flour can substitute 25% of the Maize flour, wheat, wimbi, sorghum and cassava in making Ugali, baking mixtures, porridge and dough

The following ratios are recommended:

- 1 part soy flour to 5 parts maize flour for Ugali

- 1 part soy flour to 4 parts wimbi flour
- 1 part soy flour to 3 parts wheat flour for dough in Chapatti, Mandazi, Biscuits, pancakes and cakes
- 1 part branched soy beans/cotyledons to 3 parts maize grain in Githeri

Soy beverage

- Select the soya beans by sorting out the spoilt ones
- Roast on open fire like groundnuts till brown
- Cool and take to mill
- The ground soya bean is the beverage since it is used as tea leaves
- Keep the beverage in a tight clean container with lid and cover well
- Keep in a dry, clean, well ventilated place and use as need arises

Soy milk

Ingredients

- 1 cup dry soy beans
- 5 cups water(for boiling the beans in)
- Hot water for rinsing the boiled beans and cold water to wash out the hulls
- 3 cups of cold water for making the milk
- 3 teaspoons of sugar
- ¼ teaspoonful salt
- 1 teaspoon bicarbonate of soda (Optional)- baking soda

Procedure

- Clean soya beans by removing foreign matter and damaged beans. Do not wash.
- Measure water 5 times the volume of beans.- if baking soda is used- add to the water
- Gradually drop the beans into the boiling water ensuring the boiling does not stop.
- Boil the selected beans for 30 minutes then drain- first rinse with hot water and then wash in cold water once and drain while removing the husks(dehulling)- removal of the outer seed coat or hull.

The seed coat contains unwanted substances that cause bitterness and bad smell. The hull can be removed by dry method or wet method.

- Pound with pestle and motor or use grinder

- Add 3 cups of water to 1 cup of pound soya beans, mix well then sieve with cloth
- Boil the milk and use as need be.
- The remains from the milk(paste) can be used to add to other foods like vegetables or chapatti mixture
- One can also use the whole paste for stew before removing the milk to make it more nutritious
- The used paste can also be dried and mixed with cereals and ground into flour.

DRYING AND PRESERVATION OF FRUITS AND VEGETABLES

Although there are many similarities between the processing of fruit and vegetables, it is important to realize the following differences.

- Fruits are nearly all acidic and are commonly called “high acid” foods. This acidity naturally controls the type of micro-organisms that are able to grow in fruit products. The spoilage microorganisms that are likely to be found in such products are moulds and yeasts, which if consumed, rarely cause illness. Processing may be achieved by using preservatives such as sugar, salt and vinegar, and by drying, concentration or fermentation.
- Vegetables are less acidic than fruits and for that reason are classified as 'low acid' products. A wide range of micro-organisms are able to grow in moist low-acid products, which may lead to spoilage and the possibility of food poisoning. To prevent this, vegetables can be processed by heating to destroy bacteria, or by pickling, salting, or drying to inhibit bacterial growth. Care is needed when processing low acid products, such as vegetables, to minimize the risk of transmitting food poisoning bacteria to consumers

Processing.

During drying, many fruits and vegetables experience some changes in colour. These can be

lessened by carrying out some simple processing stages prior to drying (for example, blanching).

Blanching is a short heating treatment in water or steam, and is often a necessary processing stage. It has many functions, but essentially it destroys enzymes which are responsible for causing browning, and reduces the total number of micro-organisms in the food.

For production on a small scale, the produce can either be wrapped inside a muslin cloth or in a wire basket, or immersed into boiling water for 30 sec. As the food is in direct contact with the water there is some loss of water-soluble vitamins.

Steam blanching can be carried out by placing the produce in a strainer, which is then fitted over a pot of boiling water and covered with a lid to prevent the steam escaping. Steaming takes a few minutes longer than the water method but it has the advantage of losing fewer nutrients, as vitamins are not leached into the water. For larger production, a tray blancher can be purchased.

Fruits and vegetable drying

Drying is a method of preserving food by removing the moisture (water). The main aim of drying is to take out as much water from the fruit as possible so that the spoilage organisms are not able to grow and multiply in the fruit during storage. Some fruits that can be dried include mangoes, pineapples, pawpaws and bananas.

Drying techniques

The simplest method of drying is to lay the foods in the open air, either on mats, or on raised platforms. Although this is effective, there is limited control over the drying process which results in a variable product quality and a greater risk of contamination. To give more control over these aspects, solar dryers have been designed which protect the product from dirt and insects and increase the rate of drying.

Solar dryers fall into two categories - direct or indirect. In a direct dryer, the product is exposed

to the sun's rays. This exposure results in vitamins being lost and a darkening in the colour of some foods. This colour change is desirable for products such as dates, but for lighter fruits, such as papaya and apricots, it is a problem.

Indirect dryers shelter the product from the sun. The heat from the sun is collected in a separate connected chamber and the heated air is passed over the food in an enclosed dryer.

Designs are also available for combined dryers. These are fitted with both a heater unit and a solar collecting chamber. When there is plenty of sunshine, the solar collector can be used, but the heater can also be used in poor weather conditions and at night.

There have been numerous designs for solar dryers, but most have met with a very poor response from rural producers. Most rural consumers are not willing to pay more for a slightly improved product quality and the investment in a dryer may not prove to be economically advantageous. In addition the relatively poor control over drying conditions compared to that for fuel-fired or electric dryers, means that they are largely unsuitable for high-value products such as spices, where an improvement in quality does generate higher income.

There are also a large number of designs of fuel-fired dryers. These have better control over drying conditions and therefore produce a higher quality product. They are able to operate at all times of the day and year, and in most cases produce a higher rate of drying. However, these benefits must be evaluated against higher capital and operating costs.

Advantages of solar drying

- Food in the cupboard for later use increases household food security.
- It creates employment opportunities and a sustainable income.
- Dried products improve family nutrition because fruit and vegetables contain high quantities of vitamins, minerals and fibre.

- For diabetics -dried fruit prepared without adding sugar is a healthy choice instead of desserts.
- Dried fruit can be used in stews, soups and casseroles or enjoyed as snacks. It can also be added to cereals for breakfast or used in making ice cream and baked products.
- It improves the bargaining position of farmers. Sometimes farmers sell at very low prices during the harvest season because they cannot store or preserve their surplus products.
- People are encouraged to establish their own gardens.

Precaution

- Cleanliness and hygiene are very important in the processing of dried fruit and vegetables.
- To minimize the possibility of contamination, any person who is unwell or has infected wounds or sores, is ill with a gastric disorder or suffering from diarrhoea **must be excluded** from the processing operations.
- All cuts have to be covered with waterproof dressing.
- Raw materials contaminated by moulds must not be used in processing.

Pre-drying treatments:

Selection

- Use only ripe, good-quality fruit and vegetables.
- Select fruit and vegetables individually. Discard rotted, damaged or diseased fruit and vegetables.
- Remember, processing cannot improve poor-quality fruit or vegetables.

Washing

- Clean all working surfaces before handling fruit or vegetables.
- Water for cleaning must be treated with a household bleach (disinfectant) solution. One bucketful of the treated water (20 litres) is enough for cleaning 20 kg of fruit.

- Use a fresh cleaning solution every day
- Selected fruit and vegetables should be washed and scrubbed individually in the treated water, while plastic gloves should be worn.
- Care must be taken to avoid breaking the skin of the fruit during cleaning and thereby contaminating the flesh.
- Washed fruit and vegetables should be placed into a clean basket or bucket and taken to the peeling or blanching area

Blanching

Before drying, all vegetables should be blanched in steam to halt the action of enzymes. Do not under blanch, because the enzymes will not be inactivated totally and the dried vegetables will deteriorate during storage.

Blanching Procedure

- Pour some little water into a large cooking pot that has a close-fitting lid. Heat the water to boiling and place over it, high enough to keep clear of the water, a wire rack or basket holding a layer of the vegetables (not more than 5 cm deep). Cover and let the vegetables steam for half the required time, then test to make sure all pieces is reached by the steam.
- A sample from the centre of the layer should be wilted and feel soft and heated through when it has been properly blanched.
- Remove the vegetables and spread them on paper toweling or clean cloth to remove excess moisture while you steam the next load. Cover with toweling while waiting for further treatment or before taking them to the drying trays.

Peeling

- Hygiene is of utmost importance when peeling.
- The operator should wash his/her hands and arms thoroughly with clean water and unperfumed soap.
- Clean, sharp stainless steel knives must always be used.

- Peelings and seeds should be disposed of as soon as possible because they attract flies and other insects.

Cutting and slicing

- Thickness of fruit pieces depends upon the kind of fruit being dried.
- Thicker slices will dry at a slower rate than thinner pieces. Should not be too thin or too thick
- Cutting knives and working surface have to be cleaned with a bleach solution before use.
- Slices should be placed in clean bowls which have been rinsed with clean water ready for loading onto the drying trays.
- Before loading the trays, these have to be brushed clean and washed

Driers

- Trays should be washed and cleaned to remove any fragments of dried fruit or contamination.
- Start to load during slicing rather than waiting until all the fruit has been sliced or cut. (This reduces the problem of sticking together in the bowls and will allow drying to start as soon as possible.)
- Lay the pieces of fruit on trays carefully and close to each other without overlapping to ensure the trays are loaded fully.
- Keep flies away and load trays quickly and continuously

Drying

- During the first few hours of drying, particularly during very hot and sunny weather, fruit may dry at such a rate that moisture condenses on the inside of the plastic covers.
- This can be avoided by opening the loading doors slightly (20 mm) to improve air circulation. The gap should, however, be covered with mosquito mesh.
- Doors should be kept open for a minimum period of time and closed again as soon as the weather becomes cloudy.

- In poor weather drying will stop. Rain will rapidly cool the dryer and this will result in a moisture film on the cover because of condensation. It will be some time before the dryer functions again after the sun breaks through. Therefore, protect the dryer from rain.
- Under fine and sunny conditions the fruit slices should be dry after 2 full days in the dryer. However, it is essential to test slices. If the slices are not sufficiently dry, they will become mouldy in a short time. A test for dryness is conducted for specific products.
- If the slices are not sufficiently dry, the process should be allowed to continue for 1 or 2 hours before checking again.
- The final moisture content of dried fruit should be approximately 10 % (on a wet basis).

Unloading the dryer

- When the fruit is considered to be dry, the dryer should be unloaded as soon as possible. This must not be carried out in the early morning because dew and high humidity overnight may cause condensation of moisture onto the fruit. The best time to unload is in the afternoon on a sunny day.
- Trays should be removed from the dryer and taken to a clean and covered area for removal of the dried product.
- The operator must wash his/her hands and ideally wear clean gloves when handling the fruit.
- The dried fruit should be stored temporarily in clean dry baskets before packaging so that the product can cool down.

Packaging and storing

Packaging should be carried out immediately after unloading and cooling because the dried slices will reabsorb moisture and be susceptible to attack by insects and other pests.

Proper storage should take place in the absence of moisture, light and air.

- The use of brown paper bags folded tightly and then placed inside plastic bags is recommended.
- Store in small quantities to avoid large-scale contamination.
- Pack carefully to avoid crushing the vegetables.
- Glass containers are excellent, but these should be kept in a dark area.
- Each bag or glass container should be marked clearly with labels containing the date of packaging.
- The dried products must be stored in a cool, dry and clean area which is secure and protected against rodents and other pests.

Drying of Specific products

Fruits

1. Mangoes

- Select firm, ripe mangoes
- Wash with clean water
- Peel and Cut into slices (2 - 3 mm thick)
- Arrange on trays for loading into the dryer
- Test for dryness: slices should be pliable, without sticking together

2. Pineapples

- Select firm, ripe fruit,
- Wash and cut off the top and base
- Peel and cut into slices (2 - 3 mm thick)
- Arrange on trays ready for loading into dryers
- Test for dryness: slices should be pliable, without sticking together

3. Bananas

- Select good-quality fruit
- Wash, peel and remove the 2 tips
- Slice into pieces (3-5 mm thick)
- Arrange in single layer on trays.
- Load trays into dryer
- Test for dryness: slices should be pliable, without sticking together
- Remove when dry and pack in moisture proof containers and store in a cool, dark, dry store.

1. Dried Pawpaw Slices:

- Select and wash firm ripe Pawpaw.
- Cut into quarters; remove pips (seeds) and threads.
- Peel and trim off defective parts.
- Cut into 2-3mm thick slices.
- Meanwhile prepare a syrup in the following ratio.

Vegetables

a) Pumpkin leaves

- Select fresh, tender leaves
- Peel off the hairy outer skin
- Wash in clean water and
- Steam blanch for 3 to 5 minutes
- Place on trays ready for drying
- Test for dryness: crumble easily

b) Tomatoes

- Select fresh ripe fruit
- Wash in clean water
- Cut them into quarters and remove seeds.
- Sprinkle the pieces with salt on the inner surface.
- Slice into regular pieces (vertically)
- Arrange the pieces on the tray for drying
- Uncoil the tomatoes from time to time (takes 2-3 days to dry)
- Test for dryness: a handful will spring apart after squeezing
- Remove from trays and pack in brown absorbent paper bags.

c) Amaranth sp.

- Select young, tender and crisp leaves
- Wash and place loosely in a steaming basket and steam for 3 to 5 minutes or until well "wilted"

- Spread sparsely on drying trays, keeping overlaps to a minimum
- Test for dryness: crumble easily

2. Sweet potatoes

- Select firm and smooth potatoes
- Wash and steam in small quantity of water until the potatoes are just tender (30-40 minutes)
- Peel and slice into pieces (3-5 mm) or shred
- Arrange the pieces on trays for drying
- Test for dryness: slices extremely leathery, not pliable, shreds are brittle

3. Carrots

- Choose crisp, tender carrots without woodiness (Not necessary to peel good, young carrots)
- Steam until cooked through but not mushy (about 15-20 minutes depending on size)
- Remove whiskers, tails and crowns
- Cut into rings (2-3 mm) or shred
- Arrange on trays for drying
- Test for dryness: slices very tough, but can be bent. Shreds are brittle

4. Dried Onions

- Remove the tops, roots and integuments.
- Wash Thoroughly
- Slice the onions into 3mm thick slices.
- Spread evenly on trays.
- Dry up to 5% moisture content (Ratio of prepared raw materials to dried product is 9:1)
- Remove when dry and pack in moisture proof containers. Put in cool, dry, dark store.

References:

1. Food cycle technology source books: DAIRY PROCESSING

CHAPTER 15: NATURAL RESOURCES MANAGEMENT

1. Introduction

Natural resource management deal with creating sustainable solutions for conserving natural resources such as clean water, energy, minerals and biological resources.

It deals with managing the way in which people and natural landscapes interact. It recognizes that people and livelihoods rely on the health and productivity of our landscapes and their actions as stewards of the land play a critical role in maintain this health and productivity.

2. Renewable energy technologies in sustainable ecological agriculture

Renewable energy technologies enable us to create electricity, heat and fuel from renewable sources.

Simple technologies for small scale farmers include:

1. Solar cookers

A solar cooker is a device which uses the energy of direct sunlight to heat, cook or pasteurize food or drink. Many solar cookers presently in use are relatively inexpensive, low-tech devices, although some are as powerful or as expensive as traditional stoves and advanced, large-scale solar cookers can cook for hundreds of people. Because they use no fuel and cost nothing to operate, many nonprofit

organizations are promoting their use worldwide in order to help reduce fuel costs (especially where monetary reciprocity is low) and air pollution, and to slow down the deforestation and desertification caused by gathering firewood for cooking.

Solar cooking is a form of outdoor cooking and is often used in situations where minimal fuel consumption is important, or the danger of accidental fires is high, and the health and environmental consequences of alternatives are severe

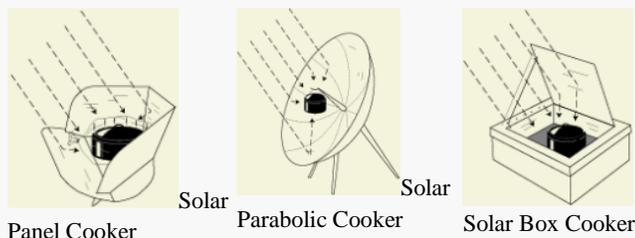
How Does Solar Cooking Work?

Solar cooking is done by means of the sun's UV rays.

A solar cooker lets the UV light rays in and then converts them to longer infrared light rays that cannot escape. Infrared radiation has the right energy to make the water, fat and protein molecules in food vibrate vigorously and heat up.

It is not the sun's heat that cooks the food, nor is it the outside ambient temperature, though this can somewhat affect the rate or time required to cook, but rather it is the sun rays that are converted to heat energy that cook the food; and this heat energy is then retained by the pot and the food by the means of a covering or lid.

This occurs in much the same way that a greenhouse retains heat or a car with its windows rolled up. An effective solar cooker will use the energy of the sun to heat a cooking vessel and efficiently retain the energy (heat) for maximum cooking effectiveness.



2. Solar drier

A basic box-type low-cost solar drier can be constructed at home or by village artisans. It is made of wire-mesh trays in a wooden framework surrounded by a clear plastic sheet. The solar cabinet dryer type has a surface of 10 m² and is capable of drying 20 to 35 kg of fresh produce (depending on commodity) over a period of 3 to 4 days. Smaller portable models of the dryer can be constructed depending on available funds for the dryer, construction and the purpose of drying (home consumption or marketing).

3. Fireless cooker

The fireless cooker, retained heat cooker or food warmer can be built with locally available materials and is used to keep food warm and to allow the cooking of food with less fuel.

To use a fireless cooker, first bring food to the boiling point using a three stone or improved cook stove, or gas or electric stove. The stove can now be extinguished and the food is put into the fireless cooker which is well insulated and keeps the food from cooling down.

The food cooks slightly slower than if it was directly on the stove, but the saving in firewood can be large.

It has many advantages in convenience - it is portable, and can be carried around easily. A well-made fireless cooker can keep food warm for up to 8 hours after it has been heated, taking away the need to plan exactly when the food must be ready. Also, it does not require watching the stove,

There is no risk of burning a pot in a fireless cooker, and there is no flame to cause a household fire or health problems (indoor air pollution).

Much less heat is produced - only a fraction of that produced in regular cooking. This heat might otherwise flow into the rest of the house, as well as making the kitchen uncomfortable. Thus it can save energy and money on air-conditioning. This is especially valuable in a warm or hot climate, or in a small or poorly-ventilated kitchen

Materials and requirements

- Basket - A simple basket that can be bought cheaply from any market - a bag or paper box could alternatively be used. It needs to be large enough to house a saucepan inside
- Lining material - e.g Jute, cotton, woolen, bark cloth (normally an piece of material from an old sack is used)
- Flat stone (clay is best)
- Sand or wood ash
- Metallic plate
- Material to use as thread
- Large needle for sewing the bag
- Insulation material - e.g cotton, wood shavings, dried grass, paper, dry leaves

Construction

- The basket is the main structure of the fireless cooker. On the inside of the basket will be a lining made from the lining material. In between these two layers, the insulation

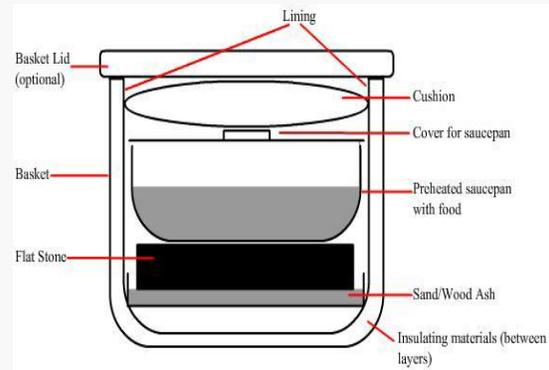
material is stuffed. This ensures that no heat is lost from the cooker

- Take the lining material and cut it so it can be used as a lining for the bag. It needs to be slightly bigger than the basket as the lining is attached on the outside of the basket (see image)
- Take the basket and very densely pack with insulation material. Place the lining on top (at this point ensure that the saucepan just fits inside. If not remove some insulation until it does.
- Sew the lining to the outside of the basket (see image)
- The metallic plate is now put inside the basket, it is filled with the sand/wood ash and the stone is put on top of the plate. This ensures that the heat of the saucepan is evenly spread

Cushion

- To cushion is put on top of the saucepan to ensure no heat escapes. This is made out of the lining material and should be exactly the width of the basket
- Make two identical pieces of lining material, making them of a diameter slightly larger than the basket. Sew them together except for a small gap
- Stuff the gap very densely with insulation material. Then complete the cushion by sewing the gap

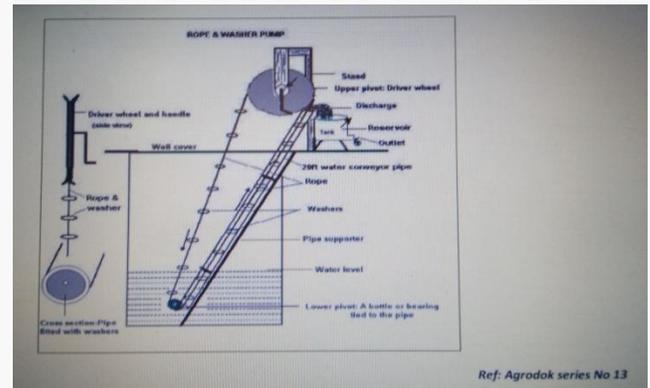
The cross section shows how the fireless cooker is used with food



Additional appropriate technologies

a) Rope & Washer pump

Rope and washer pump is an appropriate way of pulling up water from relatively shallow wells of up to about 20 feet in depth for domestic use, livestock or irrigation. The water is trapped between the washers placed about one foot apart, and pushed up through the pipe when the whole 'rope and washer' mechanism is engaged. When a person rotates the driver wheel (upper pivot), the washer carrying rope is compelled to move up through the pipe. Upon turning on the lower pivot, the washers that are below the water surface draw and force water into and up the pipe. Constant rotation and movement of the rope and washers means more water being drawn and being forced up without receding to the pipes end and discharged into the reservoir from where it can be directed.



3. Integrated watershed management.

The water available to a farming system is firstly determined by the ratio of precipitation and evaporation (including transpiration) of water. When rainfall exceeds evaporation and transpiration, there is generally enough water available for plants to grow. In the other case, water availability for crops decreases. How much water can actually be used by the crops is also determined by the (natural or man-made) water flow, run-off, and percolation.

Watershed managements integrates water management, soil protection, as well as health and socio-economic topics into a process, ideally leading to a sustainable and economically viable environment and to sufficient household income.

A **watershed** is defined as any surface area from which all rainwater is drained into the same water catchment. Small streams merge to larger streams, continuously growing to a river or filling up a lake. The watershed resembles a tree, where leafs lead to small branches and these small branches lead to larger branches and so on, eventually reaching the trunk of the tree. Watersheds include both biophysical and socio-economic characteristics, i.e. climate, drainage and water, soil, vegetation, topography as well as population, farming systems, social setups, economic activities, vulnerability profile, gender, etc

Watershed management has the goal to firstly assess the water system and subsequently develop measures to sustainably use water resources and protect the land from degradation. Furthermore, watershed management also includes integrated resource management and land protection in order to improve and enhance health and quality of life of the adjacent communities.

Participatory community watershed management from the beginning involves local farmers, other land users, and the wider community into the process.

Principles in integrated watershed management

- **Participatory** -The communities of the respective watershed need to be involved in all stages of the watershed development process, i.e. planning, implementation, and management.
- **Gender sensitive** -Mostly women suffer from the condition of uncoordinated water management, since they have to gather the water for the household use. They are the key to ensure the sensibility and sustainability of the process.
- **Build on local experience, and strengths-** Local knowledge is essential to improve existing technologies and adapt new ones. Best practices should be identified and disseminated.
- **Realistic, integrated, productive, and manageable-**Watershed development planning should be realistic and build on local capacity and locally available resources. Integrated management of the local natural resources and optimal use of social resources are essential parts of watershed development. Production and conservation aspects should be included, so households quickly receive benefits for their engagement.
- **Watershed logic and potential respected-**The watershed development activities have to follow the logic of the watershed. Simple land use and features descriptions can help to adapt to the local conditions.
- **Flexibility at different levels-**Flexibility and adapted management is needed for a pragmatic implementation and management of a watershed development plan.
- **Cost-sharing and empowerment/ownership building-**Cost-sharing by stakeholders contributes to the sustainability of a project. Also other forms of local contributions are possible.
- **Complementary to food security and rural development mainstream-**Additional elements such as basic services and social infrastructures can be intergrated in watershed planning.

Watershed size

A single household is a unit too small to efficiently manage a watershed. Watershed management is the duty of at least a whole community, if not a higher administrative unit.

Watershed management can even be done for a whole country.

Appropriate sizes of watersheds to be managed within a community are with some exceptions between 200 and 500 hectares. In bigger areas, sub-watershed units should be defined and prioritized for key interventions. A community watershed should include:

- most parts of a community comprising the smallest unit available;
- more than one community where the interactions between two or more communities are closely linked to the watershed they share;
- only a portion of a community that is widely scattered having more than one main watersheds cross the community.

In the latter case, several sub-watershed plans can be developed and linked one to the other. The links between sub-watersheds are not always obvious and evident. The interactions are not only on drainage and surface runoff but also on land use and socio-economic factors. Thus, in general, overall watershed treatment is required.

Watershed degradation

Degradation of a watershed can have various forms: depletion of water resources, soil erosion and land degradation, impoverishment of the vegetative cover, and damage to the infrastructure.

Land degradation is responsible for reduction of the vegetation cover. It can be caused by inadequate land management, overexploitation, and reduced soil fertility, but also by climatic factors. A poor vegetation cover leads to a reduced infiltration rate of the water into the soil and to a loss of water through surface runoff. Surface runoff is one of the reasons for the depletion of water resources on the one hand and for soil erosion on the other hand. Most of the surface runoff is not controlled or effectively used and so lost for the community. In order to profit from the rainwater it has either to infiltrate into the soil and be available for crop production or be intercepted

and actively used for different purposes such as use as drinking water or water for irrigation.

Runoff water also leads to soil erosion and further land degradation, which reduce soil depth and fertility, further reducing the vegetation cover. Erosion is enhanced by excessive exploitative use of the land such as the cultivation of steep slopes, shallow soils, tillage, overgrazing, encroachment of forests, etc.

Another big problem is the pollution of water with various hazardous pollutant like agrochemicals or microorganisms that lead to diseases in the population that consumes water from a specific watershed. Generally, biologically contaminated water (contamination with microorganisms) can be treated to get safe drinking water. In contrast, chemically polluted water cannot be regenerated. Thus, prevention of pollution and, hence, the protection of the water quality, is crucial within a watershed.

This vicious circle of land degradation, erosion and depletion of water resources could ultimately lead to desertification and disappearance of the potential of the land to sustain life and livelihoods.

Benefit of watershed management

• Water harvesting opportunities

Water harvesting is one of the key elements of watershed management, playing a key-role in improving people's livelihoods through providing opportunities for income generation, restore and enhance land productivity, support the rehabilitation of degraded lands, enhance the development of natural resources, and contribute to small-scale infrastructure development.

• Sustainable source of safe drinking water

A well managed and protected watershed provides its population with a sustainable source of safe drinking water. Common waterborne diseases like Amebiasis, Schistosomiasis, Cholera, etc. can be prevented by the use of safe drinking water from a

sound watershed, if needed in combination with specifically applied treatment methods.

- **Land rehabilitation, reclamation and productivity enhancement**

Current trends of land degradation rates indicate a clear need to conserve and protect watersheds. Rehabilitation of degraded areas is essential for exploiting the water harvesting potential of the area, to protect and enhance the productivity of cultivated areas and to increase overall biomass for multipurpose uses.

- **Protection, development and sustainable management of forests**

Forests contribute to a healthy watershed in multiple ways. More forests mean a better access to firewood, forage, fruits, timber, dyes, gums, and forest related activities like bee-keeping. But forests should not be monocultural. Stable, productive and resilient agricultural systems are highly diversified. Hydrology and access to water heavily depend on composition and extent of forest coverage as well as the status of re-vegetated areas.

- **Sustained, long lasting and effective use of rural infrastructure**

Soil erosion and lack of vegetative cover seriously affect the road network. With an active watershed management, road networks will benefit, most of all in fragile and steep terrains.

- **Promotion of income generation activities**

Taking advantage of the multiple benefits generated by water harvesting and moisture conservation, an increased productivity and diversity of crops, fodder and trees can be reached and the household income can be significantly improved. New income sources can be found in the process of watershed planning, for example production and marketing of new crops or other activities like tourism.

- **Watershed development and conflict resolution**

Participatory watershed development has the potential to resolve conflicts during planning and implementation through building the assets base of

farmers and generating a wide range of new opportunities and benefits.

4. Afforestation and reforestation

Afforestation

Afforestation and reforestation both refer to establishment of trees on non-treed land. Reforestation refers to establishment of forest on land that had recent tree cover, whereas afforestation refers to land that has been without forest for much longer. A variety of definitions differentiate between these two processes. Some definitions of afforestation are based on phrases such as "has not supported forest in historical time;" others refer to a specific period of years and some make reference to other processes, such as "under current climate conditions." The IPCC Guidelines define afforestation as the "planting of new forests on lands which, historically, have not contained forests."

Other issues, however, affect the application of these terms. These issues relate to the sequence of human activities prior to, and the actual mode of establishment of, new tree

Afforestation is highly important to maintain the biodiversity. Deforestation is the conversion of forested areas to non-forest land for use such as arable land, pasture, urban use, logged area, or wasteland..

Benefits of afforestation and reforestation

Biodiversity Protection: In addition to the climate benefits, reforestation has the potential to preserve endangered species. A recovering forest restores habitat loss and degradation, leading threats to species health.

Forests help to fight against global climate change and help restore endangered species from extinction. It will also enable humans to better address world hunger issues as well as issues dealing with water usage and availability.

Erosion control and watersheds management:

Deforestation damages and destroys habitats through erosion. Forest restoration can reverse the damage done by erosion. Regional watersheds, a vital resource for human development, adversely impacted by deforestation can be brought back to health through reforestation. We can reverse the damage done, but only if we act.

5. Waste management

Waste management is defined as the discipline associated with the control of generation, storage, collection, transport, processing, recycling or disposal and monitoring of waste materials in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics and other environmental considerations. The term usually relates to materials produced by human activity and is generally undertaken to reduce their effect on health, environment or aesthetics.

Waste management is also carried to recover resources from it. Waste management can involve solid, liquid, gaseous or radioactive substances.

Solid waste means all bio-degradable or non bio-degradable materials including but not limited to garbage, rubbish, refuse, ashes, and sludge from sewage treatment, construction and demolition wastes, dead animals, discarded home and industrial appliances, wood products and by products and other inert materials.

Liquid waste-This is any waste in liquid state of matter. Liquid waste can contaminate land and pollute waters and needs to be managed in a way that protects the environment and the community. This can be prevented by appropriate handling and storage of the liquid waste. Liquid waste also poses a serious threat to human health and environment because of their ability to enter watersheds, pollute ground water and drinking water

Examples of Waste materials

- Hazardous wastes such as liquid, semi solid or solid wastes which are toxic, corrosive flammable, explosive, infections, irritant or strong sensitizers(causing allergic reaction), and which constitute a high degree of hazard to beneficial air, waste and ground uses.
- Animal by products
- Biodegradable waste
- Sharps waste
- Toxic waste
- Recyclable waste
- Packaging waste/post consumer waste
- Litter
- Construction and demolition waste
- Farm waste
- Domestic waste/household waste/kitchen waste
- Electronic waste
- Grey water
- Human waste
- Industrial waste
- Waste water
- etc

Waste management concept

There are a number of concepts about waste management which vary in their. One of the mainly used concept is the “3 Rs” approach/waste hierarchy

- Reduce-prevents the generation of waste from the source
- Re-use- involves directly re-using raw materials for manufacturing and re-processing
- Recycle-turns waste into a valuable resource
- This remains the cornerstone of most waste minimization strategies.

The main aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste

Waste prevention, waste reduction and avoidance

The preferred way to reduce waste is not to make it in the first place. Meaning, less waste you have to start with, the less you will have to recycle, compost, reuse and so on.

- Writing on both sides of a sheet of paper, using products that last longer, using voice or email messages
- Other waste recycling ideas include using mulching lawn mower, buying products with minimal packaging, removing your name from mailing lists etc
- Some methods of waste avoidance include reuse of second hand products e.g. use of plastic containers for water treatment (solar treatment)
- Repairing broken items instead of buying new
- Designing products to be refillable or reusable (such as cotton instead of plastic shopping bags)
- Encouraging consumers to avoid using disposable products (such as disposable cutlery)
- Etc

Some steps to be undertaken to address waste management

1. Social responsibility for waste management should be initiated at all levels of our education system right primary school level upwards
2. The role of the community in waste management should be strengthened
3. Primary collection and involvement of informal waste recyclers is of prime importance in plastic waste management as it will help reduce waste and enable collection of waste from inaccessible areas.
4. The Kenyan government should be made aware of the positive benefits of plastic waste recycling so that they can include recycling in national policy formulation and budgetally support
5. Encourage minimization/reduction, re-use and recycling of solid waste by all solid waste producers and consumers

6. Enhance and sustained market for recycled plastic products
7. Need for capacity building on waste management
8. Creation of awareness through formal and informal education with assistance of the print and electronic media
9. Using the environment day to disseminate best practices and technologies for managing plastic waste.
10. Enforcement of policy framework and legislation

6. Riparian and wetland management

Riparian areas are lands adjacent to dams, rivers, springs, streams, lakes and wetlands that support vegetation dependent upon free water in the soil.. The Survey Act of 1989, and Water Quality Regulations (2006) and Water Resources Management Rules (2007) define riparian land as being a minimum of 6 metres up to a maximum of 30 metres on either side of its banks from the highest water mark. This distance is based on the width of the river and the water volume at any given time. The Survey Act further prescribes setback distance for oceans as 60 meters. Riparian land plays a crucial role as a buffer zone for wetlands in terms of preventing soil erosion, and other causes of degradation.

Since they dissipate water energy and filter the water flowing through them, riparian-wetland areas can affect the health of entire watersheds.

Wetland management

Wetlands are generally defined as areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support vegetation this is typically adapted for life in saturated soil. Wetlands include bogs, marshes, shallows, muskegs, wet meadows, estuaries, and riparian areas.

A riparian-wetland area is healthy and functioning when adequate vegetation, landform, or large woody debris is present to dissipate energy associated with high water flow. A healthy

riparian-wetland area exhibits certain characteristics, such as:

- Purifying water by filtering sediments as water moves through;
- Reducing the risk of flood damage;
- Reducing stream bank erosion;
- Increasing water holding water in stream banks
- Maintaining in stream flows and stream banks;
- Increasing ground water supplies;
- Supporting a diversity of wildlife and plant species;
- Maintaining habitat for healthy fish populations;
- Providing water, forage, and shade for livestock;
- And creating opportunities for recreationists to fish, camp, picnic, and relax.

Wetlands and riparian areas are at risk as a result of man's uncontrolled encroachment and exploitation of wetland resources. These interfere with the biophysical environment resulting in problems such as pollution, loss of biodiversity, degradation of life support systems and global climate change. Degradation of wetlands is triggered by physical modification of the landscape, depletion of wetland biological resources through overexploitation, encroachment and settlement, wetland reclamation and conversion for change of use, overexploitation, pollution, and promotion of alien species particularly eucalyptus.

Importance of wetlands

Wetlands are important for the following reasons:

1. They provide the following ecological services:
 - Sieving up aquatic pollutants
 - Biodiversity habitat
 - Recharge underground water systems
 - Help mitigate floods by regulating storm water flow overtime and increase water retention
 - Aid in climate change adaptation: Wetlands are a key national climate change adaption strategy for Kenya by virtue of their support to flora and fauna and recharging of aquifers during dry season.
 - Nutrient retention
 - Storm protection
 - Shoreline stabilization
2. Wetlands play the following functional roles:
 - Supply of water,
 - Act as a fish source
 - Serve as a source of food
 - Provide construction material such as building poles and river beds provide clay which is used for building houses in some traditional set ups
 - Serve as habitats instrumental in biodiversity conservation
 - Support livelihoods in the form of agriculture and tourism
 - Serve as religious and cultural sites that are important to communities
 - They are instrumental in education and research
 - Provide wood fuel
 - Provide pasture

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CHAPTER 16: FINANCIAL MANAGEMENT

1. Introduction

Financial management is one of the key elements for successful farmer entrepreneurs. Effective financial management involves the following steps:

- a. Planning-**It is a good practice to develop a clear work plan. This work plan should indicate all the details about what agricultural activities you are going to engage in. A good work plan should capture some of the following key information such as:
- What is being planted and how much (e.g you can indicate that you are going to plant maize on one acre
 - The stages from planting, to selling and what needs to be done at each of these stages
 - The amount of money required and the sources of these funds

To develop a good work plan, you can get training from technical staff in MoALF and NGO staff.

- b. Budgeting-** Develop a clear budget. This should indicate how much money you need for all the activities. After creating a budget you should be able to see how much savings you need to meet the budget. At the same time you will be able to see how much money you need to borrow to meet the budget.
- c. Record Keeping-** To ensure that you manage your finances within your business, it is important to keep proper records.

Why is Proper record keeping important in financial management?

- Proper records allow you to track the performance of your farm.
- Proper records will be a key requirement for you to convince the lenders such as Banks and Microfinance Institutions to lend you money
- When you have proper records, it allows you to plan properly. For instance, when you fill out the financial requirement record

demonstrated below, it shows you at the end how much money you need, and therefore how much loan you need to apply for.

2. Financial literacy and Debt management

Financial literacy refers to the set of skills and knowledge that allows individuals to make informed and effective decisions regarding money matters. For a small scale farmer, being financially literate means that you understand the basic financial principals such as:

- Why it is important to save your money.
- How and where to open an account with eg. Financial institution, SACCO or VSLA, so that you can save your money.
- Keeping proper records of your financial transactions so that you can manage your income and expenses wisely.
- How to access financial assistance in forms of loans so that you can sustain and grow your business

When people are not financially literate, there is a big chance that they will make poor decisions that can harm their families and their businesses

Debt is money, a service or property owed to somebody. The purpose of debt is to fund assets. Debt management involves the farmer putting the following to questions in mind during financial management process.

- How much debt is appropriate for the farm business?
- What is the appropriate working capital position for the farm business?

In addition to an analysis of debt, debt management also involves topics related to lender communications. One such topic is that you should consider several factors before committing to a lender or when considering the continued relationship with your present lender:

- Is the interest rate reasonable?
- Will the lender be a reliable source of future credit?
- Is the lender committed to agriculture?

- Does the lender understand agriculture and the particular agri-business?
- Is the lender large enough to provide adequate funding for the business?
- Will business income (profit) be adequate to pay the interest and principal payments?

3. Saving and budgeting skills

Saving is setting aside some percentage of your income for later use, especially for things you are unable to afford now, or putting aside money for future use, such as sending your children to university, buying a house or car, or even starting a business. In today's society you will hear people talk about savings but do they really save? Everyone knows it's smart to save money in the long run, but many of us still have difficulty doing it. Smart money-savers need to not only save but also consider how to spend the money they do have, as well as how to maximise their income.

Why is it Important for you to Save?

- First of all, saving allows you to meet your basic household needs- such as buying food and clothing for yourself and other members of the family
- Also when you save, you can use the money later to expand your business
- When you save, it allows you also to invest your savings by purchasing other valuable commodities such as a cow...which can provide milk for the children, or you can use the money to buy improved seeds and fertilizers so that you can improve the performance of the farm.
- It is also important to save because; many organisations that provide loans will want to see that you have the capacity to save before trusting you with their money.
- Saving is also important because it allows you to deal with emergencies and unforeseeable events- such as loss of loved ones, or medical emergencies.
- Savings enable households to meet education for children and other relatives
- Savings allow you to keep your money safe

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Normally, after a farmer has harvested and sold his produce, he/she will receive payment and it is very important to save some money in a safe place. To save your hard earned money, you can consider saving it in one of the following ways highlighted below:

- You can save in formal institutions such as a Bank or SACCO
- You can also save by buying assets like a cow
- You can save by joining a village savings scheme

As the farmer plans to save, he/she needs to know and ensure to have:

- The purpose or vision for saving i.e. short, medium term or long-term
- Consistency in saving
- Discipline,
- Convenient place to save
- Evaluate cost of saving
- Safety of your savings

Before you spend or do anything with your income, as soon as your cash is in your hands, the first thing you need to do is find a way to pay yourself. This means that you will save a percentage of your income first in your savings account where you can't get ready access to it.

People who have paid jobs with a regular fortnightly income should open a separate savings account and arrange for a direct automatic transfer of the amount nominated. This will ease the temptation of using all of the money.

For village farmers and those who do not have a regular fortnightly income, it is wise to stick to your budget. The percentage nominated for savings should be set aside for depositing into a savings account. Decide on a specific cash amount to manually deposit into a savings account each month and stick to your goal.

In order to help you save better, try following these simple rules and you will be surprised how easily they work:

- Save 20% of your income. This must be the first thing you do once you have cash in your hands.
- 10% of your income should be for church activities or other valued regular activities.
- 70% of your income should be used for other expenses.

Budgeting-A budget is a plan specifying how money, will be spent during a particular period. It is a control of expenditure and helps the farmer to know his/her needs (necessities) and wants (desires)

It also helps the farmer in living within his /her means; avoiding 'unwise' spending, overspending and falling into pointless indebtedness. Always spend what is left after saving and not save what is left after spending. In addition, the farmer should know what puts money in and takes money out of his/her pockets.

It is important to follow the below steps before saving:

- Plan and set goals: Determine the big achievements you want in life, such as educating your children or building a permanent house. Then try to understand smaller goals that you need to achieve- that will eventually deliver those big goals
- Budget: By budgeting- you look at all the money you receive and all your expenditures. It helps you to see how much you can save
- Be realistic: Set realistic savings goals. It is more important to develop the discipline than to punish yourself by saving more than you can afford.
- Stick to it: Keep it going. Once you develop the discipline of saving keep it going, and always remember that there are several other ways of saving such as investing.
- Invest: You will feel very good when you can convert your savings into investments. You can invest your savings by buying assets like land, machinery, improved seeds or fertilizers

Attributes and benefits of saving in each of the different areas:

- Credit is important also in fulfilling other personal and family needs such as paying

Farmers access to credit

Accessing Credit or Borrowing is defined as taking money in cash from a financial institution, a group or from any individual; with the commitment that this cash will be paid back at some defined time in the future.

Borrowing money can be very important for meeting the costs of a farm business, meeting family subsistence needs and growing your business. However borrowing money entails taking on risk, because when you borrow, money, it has to be repaid back fully with interest, and normally within a given period of time.

Small holder farmers or small scale agribusiness owners require credit for the following reasons:

- Credit can be used to hire laborers, or farm machinery to clear and prepare the site for planting.
- To acquire improved inputs for planting- such as seeds, fertilizers, and pesticides/herbicides. Poor yields from small scale farmers are often because of use of poor input seeds and lack of other farm inputs. With access to credit, this situation can be improved
- With access to credit, small holder farmers can increase their production, so that they graduate from subsistence farming to production for sale. Therefore credit allows farmers to grow their businesses.
- By borrowing, small farmers can solve any cash flow problems. For instance, the farmer might not have enough cash to bring in a big harvest, yet his produce has ready market. Accessing credit can allow the farmer to hire labour so that the proper harvest and post harvest is done.
- To buy machinery and farm equipment

Type	Advantages	Disadvantages
Formal Institutions		
Banks	Offer high interest rates on savings • Savings are more secure – CBK supervision you can qualify to access loans	High costs and charges • Limited outreach, bank - branches might not be available in your community You might find that minimum balance requirements are too high
SACCOs	They offer high interest rates on savings • SACCO's are closer to the farmers as they can be formed by groups in the rural areas.	
Informal institutions		
Village Savings and Loans Associations (VSLs)	They are located in the rural areas, so they are closer to the farmers. It mobilizes savings from the community The savings stay within the community- not taken away to some head office- and are therefore accessible for borrowing later on	Savings accumulation is sometimes slow, and sometimes loans for borrowing are not always available when required
Merry go round(Rotating saving and loans)	Located in the village, therefore very close to the farmer Members can access a lump sum amount at once Groups are self managed by members who know each other	Its timings are inflexible. You have to wait your turn to access your accumulated saving High rate of default by members after they have received their share
Saving at Home & Investing		
Savings at home	Saving at home is a convenient method for farmers who do not have access to other formal methods of saving Money saved at home is also easily accessible for emergencies	Easy access to savings can give rise to mismanagement of the money There is also the risk of theft from other family members and relatives
Investing	Saving through Investing allows you to purchase valuable commodities such as input seeds, and fertilizers, which can be utilized in future By investing, small holder farmers can also diversify their businesses- for instance profits from maize harvest can be used to buy dairy cows- which can produce milk for sale.	You might require more money than is available to make a particular investment. For instance, your savings might be lower than the going price of a dairy cow.

school fees.

- Ability to borrow also enables small scale farmers to deal with emergencies, such as medical emergencies or death of loved ones.

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Without a doubt therefore, the ability to access credit can provide a significant improvement in the business operations of small scale farmers.

Now if you decide to go to the bank or microfinance to either save or borrow money, you should remember that you have certain rights and responsibilities

It is your right to:

- Be given enough information about various loan products for you to make a right decision
- It is your right to be given all relevant information including all the charges relating to your loan
- It is your right for the bank to keep all your information private and confidential
- If you open a savings account, it is your right to access your savings any time you need them
- You are entitled to guidance to all procedures and processes

In exchange, it is the responsibility of the farmer to ensure that:

- He/she provides information accurately and honestly to the financial institution so that they can provide the best service to you
- He/She respects the loan contract and make timely payments as per your loan schedule

And once a farmer gets the loan, He/she should remember the following big DONTs!!

- Don't forget to keep to your repayment schedule which you have agreed with your lenders
- Don't divert a loan, by using it for other purposes rather than investing in your farm. Once you do this, you are most likely going to fail to pay it back
- Don't get a loan to service another loan, this will only increase your debts and also spoil your name.

Eventually no one will want to lend you more money in future.

Possible sources of credit for small holder farmers:

4. Village saving and loaning associations/Table Banking

Type	Advantages	Disadvantages
Formal Institutions		
Banks	Banks can offer high loan amounts which can be a good option for farmers seeking farm equipment Banks also offer various agricultural products such as leasing and various other products that can be used by small holder farmers	Banks are only slowly reaching out into agriculture, and they still perceive small holder farmers as high risk. Banks also require collateral, which small holder farmers might not have. Consequences exist if loan is not repaid
Microfinance Institutions	Are closer to the small holder farmers since they are normally found in the village areas They can provide loans in small amounts which are more suited to small holder farmers Through experience of the farmers needs, many MFI's have developed products tailored to the specific needs of the farmers. Credit is normally group guaranteed, so small scale farmers can access financing even without collateral	The interest charged might be high.
SACCOs	are located in the rural areas and are near to the small scale farmers Rates of interest are generally better than those of banks or MFI's They encourage savings from members and the savings stay within the community. are a great model for savings and credit in deep rural areas where small holders are not served by other financial institutions	It is possible that SACCO's might not have enough capital to provide all the loans required by members
Informal institutions		
Village Savings and Loans Associations (VSLs)	They are located in the rural areas, so they are closer to the farmers. Resources mobilized are usually all available for borrowing by fellow village members	Accumulating Savings is often slow, and therefore funds for borrowing may not be readily available Terms often don't suit farmers (e.g. VSLAs have terms between 3 – 6 months)
Money Lenders	They are normally more accessible in the rural areas than formal lenders like banks and mfi's	Offer extremely exorbitant interest rates Failure to pay can result in dire consequences as money lenders can adopt harsh collection methods
Borrowing from Family & Friends		
Borrowing from Family & Friends	This is normally very cheap, since family and friends might not charge interest This borrowing is also flexible, as it the conditions can be determined by mutual agreement	Friends might not have the capital required for your borrowing needs. Failures to pay can cause wrangles within the family Moral obligation to family. May cause strain in family relationships if not paid

A Village Savings and Loan Association (VSLA) is a group of people who save together to save for a common purpose. The purpose of a VSLA is to provide simple savings and loan facilities in a community that does not have easy access to formal financial services.

The monthly savings of each member of the group are accumulated to form a revolving fund within which members can take small loans to meet their business or household financial needs.

At the start of VSLA, each member is issued with a passbook indicating the members' number. The passbook acts as a record for each member savings, loaning and repayment status. This record is maintained to ensure accountability and credibility of the group financial management. A VSLA is a more transparent, structured and democratic version of the informal group savings groups in the community.

The main difference with merry go round scheme is that in VSL methodology, the savings are not shared back to each member at the end of the year but are accumulated year after years as member savings. This ensures growth in terms of member savings and enhanced ability to take even large amount of loans based on the saving capacity. VSLA is also well organized and more accountable system that each member can trust and have confidence in.

VSLA Groups usually hold annual elections to elect the office bearers: chairperson, vice chairperson, secretary, vice secretary and treasurer. The roles and responsibilities of the five-person management committee are clearly defined and highly decentralized. This is to encourage the participation of all members in the operations of the group; and, moreover, to protect the group from being dominated by a single individual.

Each VSLA group is composed of 15 to 25 self-selected individuals who have a common interest. Based on the group constitution, they can meet every weekly, every two weeks or monthly where

members save through shares. The minimum saving is decided by the group and at each meeting; every member must contribute the minimum share.

The system is very simple; but the result is powerful. In a VSLA, savings are flexible across members and over time. Members do not have to save the same amount as each other; and they do not have to save the same amount at each meeting. Also, by saving more frequently in very small amounts, the poor can build their savings more easily; and this contributes to improving the security of the household.

Savings are maintained as a revolving loan fund from which members can borrow and pay at an interest agreed upon by the group. Usually, loan amounts, up to three times their individual savings are granted. The loan repayment period is guided by the group constitution in respect to the loan amount and membership period.

In addition, a group may decide to have a social fund, which provides members a basic form of insurance. The social fund serves as a community safety net and may serve a number of purposes – such as emergency assistance, festivals and funeral expenses – for the entire community, including group members and non-members.

Each group agrees upon a contribution made by all members at every meeting. The social fund is not intended to grow, but to be set at a level that covers basic insurance needs. It is not distributed back to the members at the end of the annual cycle, but remains a group asset.

At the end of the year, the group calculates the interest earned through loaning, fines and other group fees. This interest among is then shared among the group members as dividend based on the number of shares for each member. In order to track the individual savings and loan liabilities of its members, VSLAs use a simple passbook that is appropriate for groups with limited literacy and numeracy skills.

At the end of each year cycle, the members hold an AGM to look at the status of group saving and

loaning, share dividends as well as set plan for the next year cycle.

A sample passbook record for VSLA/Table banking scheme:

- Saving record

Member Name					
ID/Passport No.					
Member No.					
Date	Details	Savings	Withdrawal	Balance	Treasurer Signature

- Loan record

Member Name					
ID/Passport No.					
Member No.					
Date	Loan amount	Principle	Repayment Interest	Balance	Treasurer Signature

5. Entrepreneurship and Entrepreneurial skills

Aspiring farmer entrepreneurs face different challenges, which affect their decision to start or continue in businesses. Some of these are unique to smallholder farmers. Entrepreneurs need to plan well for their business. They need to be aware of the implication of their good planning or lack of it, decisions and actions they make to their well being, their family, their society, the environment and global community at large. Their business, family and personal well being and the environment form a tripod. All the three must be in a good balance.

Entrepreneurship is a process of identifying and starting a business venture, sourcing and organizing the required resources and taking both

the risks and rewards associated with the venture. Entrepreneurship among farmers is one of the key means of attaining the overall objective of improving their livelihoods.

Entrepreneurs are innovators who use a process of changing the current situation of the existing products and services, to set up new products and new services.

Pillars of entrepreneurship success-What makes a successful entrepreneur?

- An idea and market
- Skills/knowledge and experience
- Resources
- Motivation and hard work

Successful entrepreneurs have these four attributes. Without any of them, your business will be unstable.

- **An idea and market:** An idea is the kind of business you want to do and market is the people who will buy your products or services. A good idea is the basis of a successful venture while the availability of a market is the indicator of the sustainability of the business venture.
- **Skills/knowledge:** This refers to several business skills. (We need both theoretical and practical skills). Do we know how to produce quality products for our market? We also need business management skills. Do we know how to keep basic records so that can assess the profitability of our business? In addition we know something about our market. Do people want our service or product? How are we going to inform people that we have what they want? Who will be our customer? And how will our goods get to the market?
- **Hard work:** working consistently every day. Making money in business largely depends on you. Are you there to open your business every day? Can people rely on you? Do you sell a quality product or service?
- **Resources:** How much money do you need to start your business? The money you use to start your business is called your capital. It

often takes a lot less money than you expect, the profits to be realized is what you should use to grow your business. Starting small is the key for great entrepreneurs. Most people only talk about the business they want to start. Take some time and reflect on these things before you start.

Characteristics of a good entrepreneur (good business practices)

- Keeping daily records: With cashbooks, we should always know how much money we have and how much we spend.
- Keeping money safe: It should be banked frequently and cash locked up safely while it is within the business premises.
- Avoid giving credit as much as possible: There will be exceptions to this, but if the base line is 'no credit', then the business can establish records to track credit and practices to collect money owed to the business.
- Collecting long standing debts.
- Routinely preparing a profit/loss statement to look at the expenses and income. At the beginning, this is done weekly, then monthly or quarterly.
- When the business grows large enough, look for professionals like financial officer or treasurer to maintain daily records and check cash receipts against the records.

As a farmer, this are important business skills to learn

- Keep a daily record - This record will track where the money comes from and where it goes. This record is called a cash book and it will help you to know how your business is doing. Without records, you can never know whether we are making a profit or a loss.
- Put money in savings regularly -You should not wait till the end of the month to start saving. By then there is usually nothing left to save. Try to set aside a small amount each day. This becomes very useful during emergencies. Banks can be a safe place for your savings, but in some of the bank fees may be more than the interest to be earned. In that case, a look for cheaper options available to you.

- Avoid selling your products /services on credit- If someone has no money and cannot pay for the item, some entrepreneurs are afraid they will lose the sale if they do not give credit. But it is not a sale until it is paid for. In such a case you lose both the money you invested and the profit. Giving people credit does not make them friends. When you give so much credit to your customers that you do not have enough cash to restock, the customers will go to other enterprises and your business will fail.
- Don't allow long standing debts -Money owed to you by people is yours, and you need it to support your enterprise. Sometimes business is done with credit, but this leads to delayed payments. You need to set your terms up front and have a plan to collect payment. Sometimes you can sell your product on credit and wait for the payment for a very long time as a result you lack products to sell to other customers.
- Check if you are making a profit or loss-This should be done on a regular basis. This can only be possible if you keep records.

Financial management skills

- Preparing a Cash book – Keeping records in business entails writing down everything concerning money which happens in the business.

As an entrepreneur you need to pay yourself a salary. Very few entrepreneurs pay themselves a documented salary. What most of them do if they need money is to take it out of the cash box without recording. It is important to know where all your money comes from and goes to.

Therefore you need to record everything in your cashbook, even the salary that you earn. A cashbook does not have to be complicated. A simple note/exercise book is sufficient. When you start recording, you must do it in a systematic and consistent order, with everything clearly labelled.

Example of a Basic cash book format

Date	Detail	Revenue/ Money In	Expenses/ Money out	Description
------	--------	----------------------	------------------------	-------------

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1st April	Cash in hand	1000		
2nd April	Paid exam fee for son		200 D	Domestic
2nd April	Sale of tree seeds	2000		Business
3rd April	Savings in cooperative bank		500	Savings
4th April	Paid electricity bill for the shop		200	Business
5th April	Bought rice for Lunch		150	Domestic

Cash in hand: This is the money we have in our pocket or purse, available to spend. It is the money at the beginning of the period. It does not include your savings.

Date: The date/day when the transaction or business activity takes place.

Detail: The details of the transaction are recorded in this column.

Revenue/Money In: You record all the money you receive in the business. The revenue column tells you what money is in your pocket. If someone buys something from you and pays, you record it in the IN column, because the money comes into your business.

Expenses /Money out: You record all the money you spend or give out of the business. The Expenses column, tells you when you spend money, or give money to somebody and it goes out. When you put money into savings you record it in the expenses column because it goes out of your business cash and is set aside

Description: Indicate where the money is being debited and credited. The Description column, tells you if the transaction was for your Domestic, your Business or Savings.

Sometimes at the beginning of business you have no cash. Write a zero in the 'revenue' column. You have to have some figure there.

Ensure you record all your money transactions every day. If you give out some money, write it down. When you make sales, write them down. When you buy a drink, or you contribute to charity

or church writes it down. Without these records, we cannot tell how our business is performing.

These records:

- Tell us how our business is performing.
- Tell us where our money is going.
- Help us increase our profit and decrease our expenses.
- Help us to prepare a Profit/Loss statement using them.
- Are used when applying for a loan.
- Help us to determine the taxes need to pay

Group work

In small groups discuss a possible farm business enterprise, list possible incomes and expenses and develop a Cash book to cover one week on a separate sheet provided by the trainer

Profit and Loss statement

A profit and loss statement will help the farmer to keep track of the source of money he/she receives and where it goes. This is why you must label every entry as either: Family, Business or Savings.

By this you will know what income was earned by your business, and what it costs to run the business. But you will also know how much you are spending on your family and if you are doing it wisely. You should also keep track of your savings because it secures the future of your business and your family.

Unlike the cash book where records are made every time a transaction is done, the profit and loss is prepared periodically, either weekly at the starting stages of the business and quarterly or annually as your business grows. The profit and loss statement is extracted from the cash book.

Entrepreneurial skills and a well-written business plan provide a strong foundation for the business you hope to run. The business plan guides you to consider in advance all the elements of running a profitable business and helps you to monitor your

progress. The entrepreneurial skills on the other hand will be a great asset in implementation of your plan. This training will address the skills you

need as well as provide a business plan template for your planning.

6. Financial records and management

A. Financial requirement analysis record

- i. The record allows the farmer to capture all the important costs to be involved in the production season of a particular enterprise.
- ii. The record allows the farmer to access his financial status and the requirements for a loan

WORK PLAN FINANCIAL ANALYSIS		
Financial requirement for growing..... Year.....		
What do you plan to plant		Planting begins..... Harvesting.....
	Kshs	
Land preparation		
• Labour in land preparation	<input type="text"/>	
• Other land preparation costs	<input type="text"/>	
Total land Preparation		<input type="text"/>
Inputs		
• Seeds	<input type="text"/>	
• Tools	<input type="text"/>	

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•	<input style="width: 80%;" type="text"/>	
Total costs of Inputs		<input style="width: 80%;" type="text"/>
Planting		
• Labour for planting	<input style="width: 80%;" type="text"/>	
• Weeding	<input style="width: 80%;" type="text"/>	
•	<input style="width: 80%;" type="text"/>	
•	<input style="width: 80%;" type="text"/>	
Total planting costs		<input style="width: 80%;" type="text"/>
Harvesting & Post Harvest		
• Labour for harvesting	<input style="width: 80%;" type="text"/>	
• Other Harvest & Post harvest costs.....	<input style="width: 80%;" type="text"/>	
Total harvest & post harvest costs		<input style="width: 80%;" type="text"/>
Total Costs Required		<input style="width: 80%;" type="text"/>
Less: farmers own Contribution		<input style="width: 80%;" type="text"/>
Total Loan required		<input style="width: 80%;" type="text"/>

B. Farm Income and Expense Analysis Report

- The record will allow the farmer to capture all the different areas of income from his/her farm.
- It also allows the farmer to record all his /her expenses, including all the costs of planting in the season as well as the costs of looking after the household.
- As a result this record shows the farmer whether all his incomes are enough to meet all the costs, and how much money can be saved by the end of the season.
- This comprehensive report of income and expenditure, allows the farmer to anticipate savings which he can start to plan for

FARM INCOME AND EXPENSE ANALYSIS		
Planned Income and Expense Report for season _____ of Year _____		
Farm enterprise	_____	Planting begins.....
	Kshs	Kshs
	Budget	Actual
A. Enterprise Income		
• Income from harvest of _____		
• Other Income		
• _____		
• _____		
Total Income	<input style="width: 80%;" type="text"/>	<input style="width: 80%;" type="text"/>

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B. Enterprise Expenses		
Seeds		
farm inputs		
Labour costs		
Post harvest costs		
Other Inputs 1.....		
Other Inputs 2.....		
Total enterprise expenses	<input style="width: 100%;" type="text"/>	<input style="width: 100%;" type="text"/>
C. Farmer Household Expenses		
School fees		
Other family costs		
.....		
.....		
Total Farmer Household Expenses	<input style="width: 100%;" type="text"/>	<input style="width: 100%;" type="text"/>
D. Total Savings	<input style="width: 100%;" type="text"/>	<input style="width: 100%;" type="text"/>

C. Cash book record

Date	Detail	Revenue/ Money In	Expenses/ Money out	Description
1st April 2017	Cash in hand	1000		
2nd April 2017	Paid exam fee for son		200	Domestic
2nd April 2017	Sale of tree seeds	2000		Business
3rd April 2017	Savings in cooperative bank		500	Savings
4th April 2017	Bought farm equipment- Jembe		200	Business
5th April 2017	Bought rice for Lunch		150	Domestic
6 th April 2017	Bought seeds		200	Business
7 th April 2017	Church offering		300	Domestic

D. Profit and loss account

Mwangi tree nursery business Profit and loss account as at 7 th April 2017			
Cash in hand 1st April 2017			1000
Income (IN)		+2000	
Business	2000		
Family/domestic			
Savings			
Expenses (OUT)		-1550	
Business	400		

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Family/domestic	650		
Savings	500		
Profit and Loss			450
Cash at hand 8th April 2017			1450

This statement tells us, that Mwangi's business started the week of April 1st - 7th with Ksh.1000. This was the cash in hand. During this period, he earned an income of Ksh.2000. This is the sum of all the entries in the IN column. It is the total income for the week and is recorded on the Income line. But he needs to know whether it came from the business, or perhaps from family or from savings. In this case no money came from family or savings so under this he indicates '0'.

He also needs to know how much he spent during the week by adding the OUT column.

A total of Ksh.1550 was spent. That is written on the Expenses line. But he also needs to know what the money was spent on. He adds everything in the OUT column that he spent on the Family, Business and savings .All this adds up to 1550 (we put a minus sign because it goes out).

Recall how we calculate profit

$$\text{Income} + \text{Expenses} = \text{Profit}$$

Therefore:

$2000 - 1550 = 450$ (this is Mwangi's profit for the first week of April)

At the start the week of 8th April 2017 Mwangi's cash in hand was Kshs 1450 ($1000 + 450 = 1450$) (Add the profit to the 'cash in hand' on 1st April)

In your business you may have some 'cash in hand' at the beginning of the week you may have

spent more during that week than you received, that will show a LOSS on our profit/loss statement. If that happens you should SUBTRACT the loss from the 'cash in hand' you started the week with.

What is profit? You may think it is the money you make when you sell something. That is income. Income and Profit are different. We always need to remember expenses. Do we have to buy seeds for the farm enterprise, do we need to pay rent for the space where we make or sell our product? Do we need to pay for transportation? Do we pay salaries to the people who work for us? Those are some of the expenses of doing business.

Sometimes we do things that affect our profit, usually reducing it, without realizing it. If we run a fruit shop in the community, and we let our friends and relatives take some for free, we reduce our profit. If a farmer has a fruit seedlings seedling business and he/she gives some to the the Agricultural Extension officer who visits them, he/she reduces the profit .

Always remember this; if we make profit, It is meant to support ourselves, our family, and more Importantly, our business. Savings are vital to sustaining and expanding a business.

Remember that, the measure of success in business is when we make profit in the confinement of the larger well being of our family, business, society and environment.

References:

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2. Farm Debt Structuring and Debt Management Principles, Alan Miller,
3. Agrifocus 2011. a guide for small holder farmers on saving, accessing credit, and

CHAPTER 17: SOCIETAL CROSS CUTTING ISSUES

1. Introduction

Agriculture is one of the most important sectors in many developing countries, providing a living or survival mechanism for up to 80 percent of a country's population. Kenya's agriculture is dominated by small scale farmers (75% of the total population) this necessitates the need to mainstream and address various cross cutting issues that affect their agricultural productivity

Such cross cutting issues include

- .Mainstreaming HIV and AIDS prevention and management
- Gender and Gender based Violence prevention
- Youth and development
- Drug and substance abuse prevention.
- Conflict and dispute resolution

2. Key cross cutting issues

a) HIV and AIDS

The impact of HIV/AIDS on the macro economic environment takes two dimensions, namely the direct and indirect costs (Balyamujura *et al*, 2000: 14).

The direct costs include the cost of treatment associated with HIV related illness, which has serious implications for health care budgets around the region. Those segments of the population that are poverty-stricken stand to lose the most as pressures on the health budgets increases resulting in higher medical costs.

Indirect costs are more difficult to measure as they refer to loss of value of production, the loss of current wages, the loss of the present value of future earnings, training cost of new staff, high

staff turn-over, cost of absenteeism, higher recruitment costs, the drainage of savings, amongst others.

The impact of HIV/AIDS at the household level also negatively impacts on the macro-economic context. The repercussions of HIV/AIDS is felt most acutely at the household level, with the burden weighing most heavily on the poorest households, those with the fewest resources with which to cushion the economic impact (Barnett *et al.*, 2001: 158).

One study estimated that households experience a decline in income of between 48 percent and 78 percent when a household member dies from HIV/AIDS, excluding the costs of funerals (cited in Walker, 2002: 7). This burden readily translates into an overall cost on national development and the macro economies of individual countries, a situation aggravated by the fact that the portion of the population most affected by HIV/AIDS is the most economically active.

HIV and AIDS have a myriad of effects on sexual and reproductive health and rights, and sexual and reproductive health services are critical for women and men with HIV and AIDS

b. Gender and Gender based violence

Gender refers to a socially constructed system of classification that ascribes qualities of masculinity and femininity to people. Gender characteristics can change over time and are different between cultures

Gender Mainstreaming refers to a process of assessing the implications for women and men of any planned action, including legislation, policies or programmes, in any area and at all levels. It is a strategy for making women's as well as men's concerns and experiences an integral dimension in the design, implementation, monitoring and evaluation of policies and programmes in all political, economic and social spheres, such that inequality between men and women is not perpetuated. The ultimate goal is to achieve gender equality

Gender based violence refers to violations of fundamental human rights, based on the gender construction. It includes any act that results in, or is likely to result in, physical, sexual or psychological harm or suffering to women because of being women and men because of being men, including threats of such acts, coercion or arbitrary deprivation of liberty, whether occurring in public or in private life.

In most cases it refer to physical, sexual and psychological harm that reinforces female subordination and perpetuate male power and control

Women in Kenya face a multitude of challenges when it comes to access and control of assets. Men control access to most productive assets in Kenya (World Bank 2003

Women form the back bone of Kenya's economy which 80% dependent on Agriculture. Data from the agriculture sector shows that women do 80% of the food production, 50% of cash crop production, 80% of the food storage and transport from farm to the home, 90% of weeding, and 60% of the harvesting and marketing of crops (AfDB 2007).

Women have simultaneous and competing demands for productive (market) and reproductive (household) labor time. Understanding season calendars and daily time use are critical for designing local activities that will not deepen the time poverty of women. RODI will be sensitive to this and try to help the women and men understand the value of time in relation to each activity that they invest their time and resources on to ensure better returns and sustainable management of available resources. The division of labor is highly segmented by sex (with minimal elasticity) (AfDB 2007). Women generally plant food, weed the crops, do most of the post-harvest work, run small-scale businesses such as selling farm produce, care for the children, prepare food, clean the house, and collect water and firewood.

Women have been left to do all this work on their family land and more often they do not have the cash to pay men to help them. Some of them end up paying other women with food or men with sex and ready food.

c. Drug and substance abuse

Drug and substances abuse has become a common phenomenon in society bringing with it serious socioeconomic challenges. Different sectors are devising methods of handling this delicate issue. The agricultural sector in the country has not been left out. The sector is the backbone of the country's economy accounting for about 80% of the country's work force. Agricultural sector also contributes to about 26% of the country's GDP. However, the sector, among other factors, is greatly challenged by the existence of drug and substance abuse.

Drugs and substances abused in Kenya include:

1. Alcohol
2. Tobacco
3. Miraa/ khat
4. Marijuana
5. Inhalants and Solvents
6. Heroin
7. Cocaine
8. Prescription Drugs – including sex enhancement drugs

Causes of Drug Abuse in Kenya

1. Peer influence
2. Low self-esteem
3. Media influence (TV, magazines, internet)
4. Rebellion against parents, teachers, religion etc
5. Curiosity
6. Lack of knowledge of drugs
7. Poor role models .
8. Frustrations from home, school, body changes etc
9. Inability to achieve goals set thus feeling like a failure
10. False ideas and perceptions. e.g. bhang enhances academic performance ..

Effects of Drug Abuse in Kenya

1. Poor memory
2. Reduced reasoning capacity
3. Truancy and poor performance in school, sports and other activities.
4. Poor concentration
5. Dropping out of school.
6. Suspension and expulsion from schools .
7. Risky sexual behavior leading to early pregnancy & HIV/AIDS
8. Crimes like theft, violence, rape, incest, bestiality (sex with animals) leading to legal implications .
9. Poor health
10. Personal neglect
11. Withdrawal and isolation from society
12. Being shunned by the society .
13. Personal guilt
14. Poor relations with parents, teachers, siblings and peers .
15. Physical and psychological addiction .
16. Overdose of drugs can lead to DEATH.

Preventive Strategies to Drugs and Substance Abuse in Kenya

1. Involve yourself in pleasurable activities like games, drama, clubs and societies etc
2. Develop a good reading culture .
3. Apply critical thinking e.g. asking yourself, why am I doing this?
4. What for? What are the consequences of my actions?
5. Develop mechanisms for dealing with difficulties, issues .
6. Choose friends wisely .
7. Develop your personal potential such as creativity,
8. Appreciate, love and accept yourself as you are .
9. Identify and pursue your purpose in life .
10. Self awareness: identify your capabilities, strength, limitations, weaknesses and appreciate them .
11. Be aware of your physical, mental and emotional changes taking place during adolescence and learn to cope.

d. Youth and development

Kenya faces a significant unemployment problem with youth being hit hardest. The high unemployment is related to the overall investment climate in the country and the economy's low capacity to create new jobs. But youth find it particularly difficult to enter the labour market. Reasons for this are complex. They range from deficits in education and skills to lack of work experience, difficulties to obtain information about career options and job chances, irrational recruitment practices of employers, and the lack of necessary assets and attitudes to become self-employed.

The high rate of youth unemployment in the country has a direct link to the escalating crime rate, abuse and exploitation among the youths.

Employment opportunities for school leavers are almost non-existent making youths in particular synonymous to crime and the single most important concern facing the country. Although unemployment affects all Kenyans, youths are the worst hit; this pushes them into wayward behavior and making them vulnerable to exploitation and other social vices. The current education system although highly competitive, it falls short in equipping pupils with practical skills, that have a direct bearing in enabling Kenyans to address their felt basic needs

3. Impact of cross cutting issues to Agriculture and community development

a) HIV and AIDS

The major impact on agriculture includes serious depletion of human resources, diversions of capital from agriculture, loss of farm and non-farm income and other psycho-social impacts that affect productivity

b) Dug and substance abuse

On the overall, alcohol is the most used substance among producers and in the agricultural sector could be a serious liability likely affecting key factors of production (land, labour, capital) and

entrepreneurship in a number of ways as indicated below:

Land: Drugs and other substances are competing for the scarce land resources in the country. In parts of Eastern province for example, miraa has taken up land that would have otherwise been used for production of food crops. while cases of bhang cultivation have been reported around Mount Kenya region, among others. In highly impoverished and fragmented farm units, alcohol-prone households get predisposed to selling whatever parcels they may have been left and the danger being that part of the proceeds goes into alcohol consumption expenditure.

Labour: The youth provide on-farm labour. However, most, are in the range between 16 to 35 years happen to be the most vulnerable to drug and substance abuse. Since most of them are unemployed, they readily access cheaper local brews. The constant use of these brews leads to poor nutrition and general tends to weaken their body physiology thus reducing their productive energy and attention to their farms after consumption of drugs.

Capital: expenditure on drugs and other substances is likely to be costing Kenyan families and the country significantly large amounts of capital that would otherwise be invested in the agricultural production to improve the sector. There were widespread reports of sugarcane, coffee and tea farmers in the country resorting to local brews dens after receiving payments from their crops harvests to squander a large part of their income instead of re-investing in production, entrepreneurships and health.

Entrepreneurship: Income in profitable producer undertakings usually comes after success and rarely by the reverse. Producers prone to drug and/or substance use rarely have the patience to walk along the agriculture product value chain both in space and time and hardly seemed to grow out of the land-labour-product-capital-poverty degradation trap

Thus their personal and families economic and livelihood situation would improve.

c) Gender Based violence

Although women perform 66% of the world's work, and produce 50% of its food, they earn 10% of the income and own 1% of the world's property

Economic empowerment and gender-based violence (GBV) are closely linked. Economically disempowered women are vulnerable to gender-based violence; conversely, GBV is economically damaging, both on a micro and macro level.

“Strategies for empowering women economically to give women greater autonomy in securing livelihoods, including through self-employment, collective income-generating arrangements within households and communities, formal employment and entrepreneurial market activity, have shown some of the best-evaluated outcomes in terms of reducing participating women's future experience of violence.



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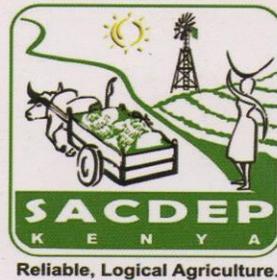
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