Sustainable Agricultural Livelihood Restoration, Rehabilitation and Resilience in Kenya

Training Manual







EMERGENCY LOCUST RESPONSE PROJECT (ELRP)

SEPTEMBER 2022

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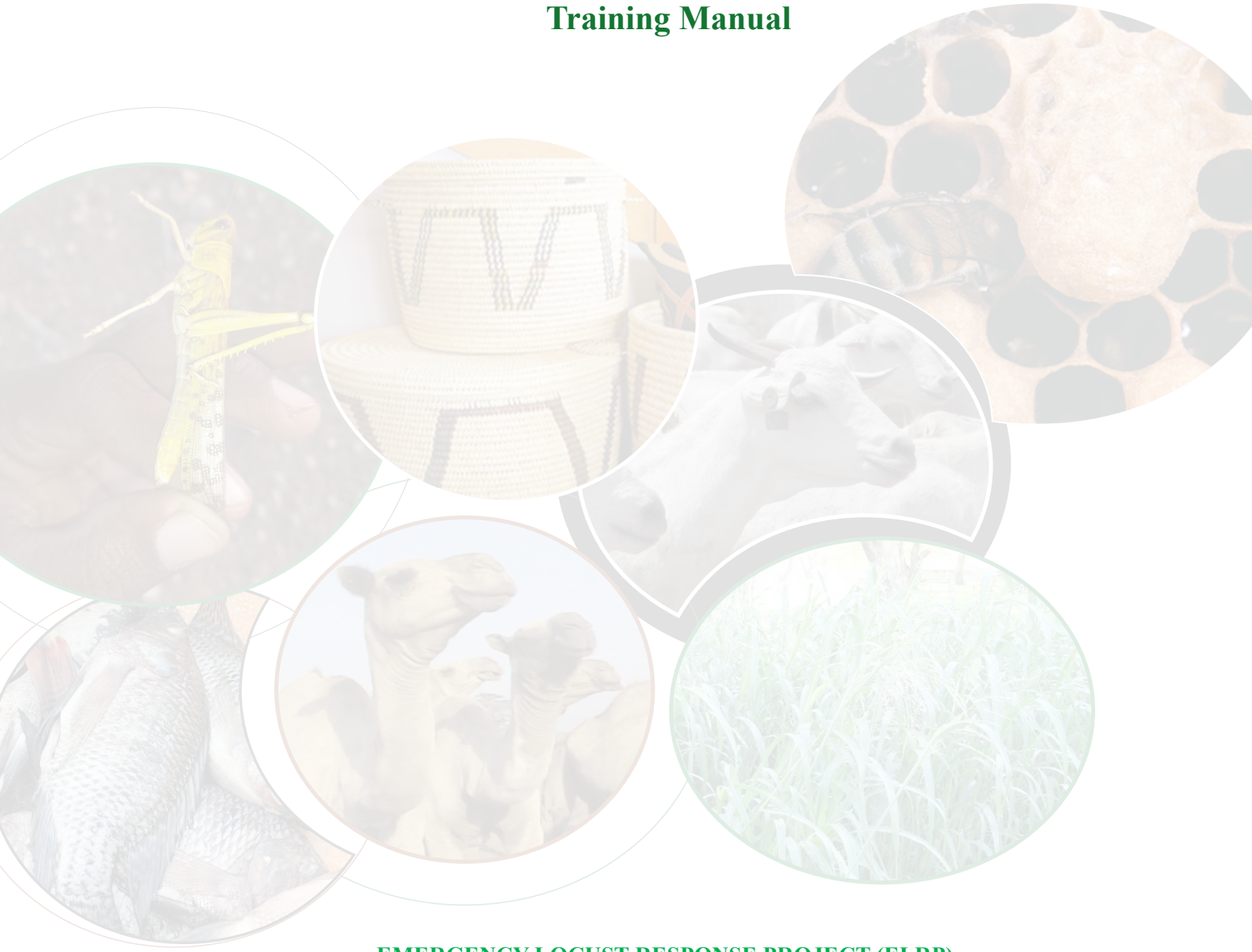

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Disclaimer

The information presented in this training manual is for advisory use only. Users of the manual should verify site-specific details that relate to their agro-climatic zones from their area agricultural extension officers.

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Foreword

The Emergency Locust Response Project (ELRP), is a four-year (2020/2021 to 2023/2024) project initiated by the Government of Kenya and supported by the World Bank. The aim of the project is to prevent and respond to the threat to livelihoods posed by the Desert Locust outbreak and to strengthen Kenya's systems for preparedness. Component two of the project is on livelihood restoration and protection. It is being implemented in 15 counties that were adversely affected by the Desert Locust invasion. The component is designed to support livelihood restoration and protection interventions among the affected and vulnerable communities through training and capacity building on best practices on relevant Agricultural Technologies, Innovations and Management Practices (TIMPs).

In this regard, manual is essential for ensuring effective, efficient and systematic delivery of best practices on relevant Agricultural TIMPs to the affected and vulnerable communities. The manual is designed to promote best practices in the design, implementation and evaluation of response and impacts on the livelihood and food security shocks arising from natural disasters.

The manual represents a synthesis of experience from practitioners working in government agencies, non-governmental organizations (NGOs) and National Research Systems (NARS) i.e. research institutions in Kenya, plus lessons learned from other countries in the region. The information was collated by Working Groups under the Emergency Locust Response Programme (ELRP), in collaboration with stakeholders and professional consultations. The manual presents best practice as it is currently known in Kenya, and will be subject to review and refinement over time.

I take this opportunity to thank the Cabinet Secretary, Ministry of Agriculture, Livestock, Fisheries and cooperatives, Hon. Peter Munya, the Principal Secretaries, State Departments of Crop Development and Agricultural Research and Livestock for their leadership and guidance in the project Implementation, and the World Bank for their financial and technical support.

Finally, I am greatly indebted to all the technical staff drawn for the ELRP NPCU, Kenya School of Agriculture (KSA) and Kenya Agriculture and Livestock Research Organization (KALRO) among other stakeholders who participated in the preparation of this manual.

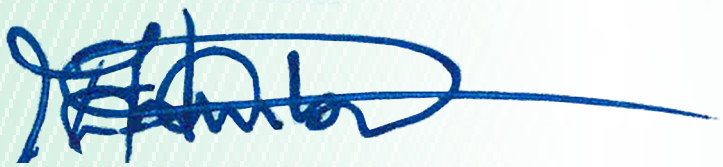
Mr. Collins M. Marangu

Director, Plant Protection and Food Safety Directorate (PPFSD)

Preface

Climate change induced disasters including droughts, floods, pests and diseases have posed challenges on food and nutrition security in Kenya. Desert Locust invasion is one of the recent disasters that occurred in Kenya ravaging crops and pastures in many parts of the Country mainly in the ASALs. The situation was exacerbated by drought that affected most of the pastoral communities in Kenya, disrupting sources of livelihoods and more so livestock production. This necessitated designing and supporting implementation of livelihood restoration and rehabilitation interventions geared towards enhancing community resilience for any future shocks. The National Project Coordination Unit (NPCU) of the Emergency Locust Response Program (ELRP), in consultation with relevant experts drawn from various institutions, have developed this manual. The institutions involved included the State Department for Crop Development and Agricultural Research, the State Department for Livestock Production, the Kenya School of Agriculture and the Kenya Agricultural and Livestock Research Organization (KALRO). The Manual is to be used in designing and implementing livelihood restoration and rehabilitation interventions among communities adversely affected by climate change and variability induced disasters. The major disasters being focused include pests and diseases outbreaks, droughts and floods. Application of the Manual is expected to ensure that communities are safeguarded and protected from loss of human, social and asset capital resulting from adverse effects of the natural calamities. Towards this end, capacity building of the affected and vulnerable communities has been identified as a key vehicle towards enhancing their resilience.

The objective of the Manual is therefore to guide the MDAs and other development partners involved in training and capacity building of communities in livelihood restoration and protection in delivery of best practices on relevant Agricultural Technologies, Innovations and Management Practices (TIMPs). Furthermore, the Manual acknowledges that there are several enablers to designing and implementing sustainable livelihood restoration and protection interventions. These include Information and communication technology (ICT) innovations; Agribusiness; Social inclusion, Gender mainstreaming, Leadership and Governance. These have been incorporated in the Manual. Appropriate training methodologies and approaches, training materials and relevant references have been provided under each module to further facilitate learning and knowledge acquisition.



Esther Wambua

National Project Coordinator

Acknowlegdement

The Emergency Locust Response Project (ELRP) acknowledges the Government of Kenya, the World Bank and the International Development Association (IDA) for financial support that enabled the production of this manual. The ELRP National Project Coordination Unit (NPCU) provided logistical support for the preparation and compilation of the manual. Scientific and technical staff of various disciplines and support staff worked tirelessly in the processes leading to successful completion of the manual.

The NPCU management wishes to recognize the scientist and technical staff from the State Department for Crop Development and Agricultural Research, the State Department for Livestock Production, the Kenya School of Agriculture and the Kenya Agricultural and Livestock Research Organization (KALRO) who worked tirelessly to make this Manual a reality.

Finally, sincere appreciation goes to the compilers under the leadership of Douglas Indetie and Catherine Kinyanjui and editors under the able guidance of Jack Ouda. Deployment of this manual will go a long way in enhancing capacity building and delivery of Best practices on Technologies, Innovations and Management Practices (TIMPs) to pastoral and farming communities affected to natural disasters. Therefore, all contributions by staff and colleagues not specifically mentioned are acknowledged with great appreciation.

ABBREVIATIONS AND ACRONYMS

ASAL	Arid and Semi-Arid Lands
CA	Conservation Agriculture
CAHWs	Community-based Animal Health Workers
CC	Climate Change
CV	Climate variability
CSA	Climate Smart Agriculture
DL	Desert Locust
ELRP	Emergency Locust Response Project
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
ICT	Information and Communication Technology
IPM	Integrated Pest Management
ISFM	Integrated Soil Fertility Management
KALRO	Kenya Agricultural and Livestock Research Organisation
KMS	Kenya Meteorological Service
MoALFC	Ministry of Agriculture, Livestock, Fisheries and Cooperatives
NCEP	National Centre for Environmental Prediction
NOAA	National Oceanic and Atmospheric Administration
NRM	Natural Resource Management
ODK	Open Data Kit
PPFSD	Plant Protection and Food Safety Department
NPCU	National Project Coordinating Unit
NLCU	National Locust Control Unit
CPCU	County Project Coordinating Unit
CLCU	County Locust Coordinating Unit
CDDC	Community Driven Development Committee
SAIC	Social Accountability and Integrity Committee
CIG	Common Interest Groups
PO	Produce Organisations
PMC	Project ManagementCommittee
PVC	Poly Vinyl Chloride
SWC	Soil and Water Conservation
TIMPs	Technologies Innovations and Management Practices
VMG	Vulnerable and Marginalised Group
WMO	World Meteorological Organisation

Background

Kenya has experienced several climate change induced disasters including emergence of pests and diseases, drought and floods among others. These disasters have posed challenges on food and nutrition security in the country with adverse effects on livelihoods. The Desert Locust upsurge experienced in Kenya between 2019 and 2021 was the worst in 70 years and affected the country's northern region posing a severe food security threat to about 3 million people. The situation was further exacerbated by drought that affected most of the pastoral counties in Kenya causing more damage to livelihoods among the affected communities.

Kenya has witnessed strong economic growth and declining poverty incidence, but absolute poverty remains high. Since 2011, the Kenyan economy has experienced robust GDP growth averaging 5.8%, catapulting Kenya to a middle-income country and significantly bringing down poverty levels. Kenya's poverty rate with respect to the international poverty line is among the lowest in East African countries, falling from 43.7% in 2005/06 to 36.8% in 2015/16 and 33.4% in 2019.

The COVID-19 pandemic reversed some of the gains in poverty reduction, precipitating Kenya's first recession in 20 years and pushing an estimated two million Kenyans into poverty in 2020. Kenya's real GDP, which was growing at an annual pace of above 5%, contracted by 0.3% in the face of the triple shock of the pandemic comprising of the health impact, the economic impact of the containment measures, and behaviour changes, coupled with reverberations from a synchronised global recession. Kenya's economic outlook remains uncertain, and the projected return to above 5% growth rate faces several potential adverse scenarios, including slower than anticipated vaccination rollout, fiscal slippages, adverse weather conditions, and a weaker global economic backdrop. Policymakers face the challenge of supporting the recovery and laying the foundation for green, resilient, and inclusive development while reducing macro-financial vulnerabilities.

The greatest impact of Desert Locust invasion and drought was felt by households that depend on livestock and cropping activities and who are already facing acute food insecurity due to their existing high vulnerability and the effects of expected fodder and crop losses. For these households, locust impacts and drought led to a deterioration in food security and a rise in food prices.

The Emergency Locust Response Program (ELRP) was thereafter conceptualised to supplement government resources against continued locust invasions. The Government accessed a World Bank credit of USD 43 million (IDA 66480) to support a holistic response to the upsurge, including: swarm surveillance and control, livelihood restoration, and improving national preparedness against future outbreaks of locusts and other transboundary pests. The project has four components; component 1: Surveillance and Control Measures; Component 2: Livelihoods Protection and Rehabilitation and Component 3: Coordination and Early Warning Preparedness and Component 4: Project Management.

This manual is developed to support livelihood restoration and rehabilitation. The objective of these interventions is to safeguard and protect the poor and vulnerable households from human, social and asset capital losses resulting from the effects of locust invasion. There will be support initiatives to enhance access to food and to rehabilitate food production systems and livelihoods that have been damaged by desert locust (DL) swarms. The affected farmers and livestock-holding households will be supported to restore their productive assets for enhanced adoption of existing and alternative Technologies, Innovations and Management Practices.

ABOUT THE MANUAL

This manual is designed to promote best practices in the design, implementation and evaluation of agricultural interventions in response to natural disasters in pastoral and agro pastoral areas of Kenya.

The manual represents a synthesis of experience from practitioners working in government agencies, non-governmental organisations (NGOs) and National Research Systems (NARS) i.e. research institutions in Kenya, plus lessons learned from other countries in the region. The information was collated by Working Groups under the Emergency Locust Response Programme (ELRP), in collaboration with stakeholders and professional consultations. The guideline presents best practice as it is currently known in Kenya, and will be subject to review and refinement over time

The manual is organised into four sections namely: (i) Livelihood analysis (ii) Livelihood restoration and rehabilitation (iii) alternative livelihoods and (iv)Enablers that facilitate the attainment of the livelihood interventions.

Intended users of the manual

The guide is intended to be used by:

- Managers and technical staff working for National and County Governments and Government Agencies who are involved in the implementation or assessment of emergency interventions.
- Personnel of Non-Governmental and Community based organisations
- Donor personnel and staff of agencies such as the United Nations Office for the Coordination of Humanitarian Affairs, and Food and Agriculture Organisation, plus any other donor.
- Universities and tertiary institutions teaching subjects related to pastoral development, rural development, humanitarian assistance, disaster risk reduction or related topics.
- Research institutes and Regional development bodies amongst others

Training methodology

- Lectures
- PowerPoint presentations
- Group work
- Demonstrations and practical sessions
- Field exercise
- Videos and Pictorial aids
- Case studies
- Simulations and role plays

SECTION ONE
LIVELIHOODS ANALYSIS

Introduction

Livelihoods analysis aims at understanding how people source, develop and use assets within a complex set of trends, shocks, and formal and informal policies and institutional arrangements. Such analysis is commonly based on a livelihood framework which categorises assets in terms of five main types of capital:

Human capital: This represents the skills, knowledge, ability to labour and good health that together, enable people to pursue different ways of making a living. In pastoralist areas, formal education and health services are often poorly supported and geographically distributed. However, pastoralists possess rich indigenous knowledge on livestock health and production.

Social capital: This is the social resources which people use to pursue different ways of making a living. Social capital includes networks, group membership, relationships of trust, and access to the wider institutions of society. The concept of reciprocity is important, as are the exchanges which facilitate co-operation. Pastoralists often have strong social capital at community level, with complex systems of indigenous social support based on the exchange of livestock.

Financial capital: This is the financial resources which people use to achieve livelihood objectives. It relates to both production and consumption, and the availability of cash (or equivalent) which enables conversion to other types of capital.

Natural capital: This is the natural environmental resources which people use to make a living. It includes soil, water, vegetation and wildlife resources, and encompasses access rights and land ownership. In general, pastoralist areas are characterised by low rainfall with high spatial variability. It is this rainfall pattern which largely determines the seasonal movement of pastoral herds (transhumance), and the seasonal variations in production and markets.

Physical capital: This is the basic infrastructure and producer goods needed to support livelihoods. In pastoralist areas, the physical capital required to support livestock production is often poorly developed. This includes roads, communication infrastructure and livestock markets.

Access to and use of these different types of capital is determined by various factors:

Seasonality: Particularly seasonal variations in rainfall, livestock production and the terms of trade for livestock and cereals.

Trends: Such as global climatic trends, the increasing occurrence and severity of drought, the growth of export markets for livestock, environmental change associated with bush encroachment, private enclosure of rangeland, and human population growth. Such as livestock disease epidemics and conflict; as drought becomes more regular and predictable it might be categorised as a seasonal factor rather than a shock.

1.1 UNDERSTSNDING LIVELIHOODS SCOPES

Livelihood strategies

Livelihood strategy is how people access and use these assets, within the aforementioned social, economic, political and environmental contexts. The range and diversity of livelihood strategies are enormous. An individual may take on several activities to meet his/her needs. One or many individuals may engage in activities that contribute to a collective livelihood strategy. Within households, individuals often take on different responsibilities to enable the sustenance and growth of the family. In some cultures, this grouping may expand to a small community, in which individuals work together to meet the needs of the entire group.

Livelihood vulnerability

The strength of a given livelihood is not only measured by its productive outcomes, but equally by its resilience to shocks, seasonal changes and trends. Shocks might include natural disasters, wars, and economic downturns. Availability of resources, income-generating opportunities, and demand for certain products and services may fluctuate seasonally. More gradual and often predictable, trends in politics and governance, technology use, economics, and availability of natural resources, can pose serious obstacles to the future of many livelihoods. These changes impact the availability of assets and the opportunities to transform those assets into a “living”. Under such conditions, people must adapt existing strategies or develop new strategies in order to survive.

Livelihood interdependence

One final important characteristic of livelihoods is their interdependence. Very few livelihoods exist in isolation. A given livelihood may rely on other livelihoods to access and exchange assets. Traders rely on farmers to produce goods, processors to prepare them, and consumers to buy them. Livelihoods also compete with each other for access to assets and markets. Thus, positive and negative impacts on any given livelihood will, in turn, impact others. This is a particularly important consideration when planning livelihood assistance.

Livelihood mapping

The livelihood mapping divides the country into areas where the rural population shares relatively homogeneous living conditions. The livelihood zone areas describe the agro-ecological and the socio-economic characteristics of the rural population, including the main livelihoods, the natural resources available, the potential constraints and priorities for development. The livelihood map is used to identify priority areas for investment according to the demand of the population. Livelihood mapping is therefore about gaining an accurate geographic and realistic cultural understanding of people’s strengths, weaknesses, opportunities and threats (assets or capital endowments) and how they endeavour to convert these into positive livelihood outcomes. It mainly considers the main livelihood zones, farm typology, potential beneficiaries and threats to such livelihoods and the possible viable sustainable livelihoods that can be adopted.

There is no one-size-fits-all approach to livelihoods. Interventions must be adapted to the local context. Different factors fundamentally change the way livelihood interventions should be designed. This Manual provides a framework for assessment to help trainers determine the right combination of interventions to arrive at a holistic approach that is

well adapted to the local context.

Emergency calamity cycle management

In the case of slow onset emergencies such as drought or desert Locust infestation, livelihood analysis highlights the need to protect assets and support the services and systems which in the long-term, are required for recovery and development. Increasingly, it is becoming questionable whether drought or desert locust infestations which are becoming cyclic and predictable may not really be a shock, but more a regular and predictable event which occurs seasonally.

In terms of the practicalities of designing Crop and livestock interventions, these can be categorised according to their relevance at a particular stage of a typical calamity cycle. Some interventions such as water supply and veterinary care are always needed, whereas other interventions are appropriate only at certain times. For example, support to commercial destocking should occur during the alarm/alert phases whereas restocking should take place during the recovery phase.

Early livelihood-based programming

- Emergency food Supply
- Cash Transfer Programmes
- Input Supplies (Seeds, fertilisers, pesticides etc)
- Commercial destocking
- Feed supplementation
- Water supply
- Veterinary care
- Ongoing drought monitoring

These Manual refer to Crop and livestock interventions during the alert/alarm phase, the emergency phase and the recovery phase. A prerequisite for an effective and timely response is a strong early warning system based on livelihoods indicators. In pastoralist areas, such systems include indicators of livestock status and market conditions; while crops are diminishing supplies of essential staples, vegetables and common food items.

Assigning different interventions to different stages in the drought cycle indicates that combined interventions are often needed. For example, in the alert/alarm phase commercial destocking to remove some animals from the rangeland should be accompanied by efforts to protect the remaining livestock, such as veterinary care, feed supplementation and water provision. The need to combine different interventions simultaneously is a challenge, particularly if different interventions are assigned to different agencies - hence the need for strong coordination. Not only are different interventions appropriate at different stages of the calamity, the intensity and scale of the intervention often needs to change during the calamity cycle. An example of activities at different stages of a drought is provided in Table 1.1.

TABLE 1.1. EXAMPLE OF THE TYPE AND INTENSITY OF ACTIVITIES REQUIRED AT DIFFERENT STAGES OF A CALAMITY CYCLE

Stage of calamity cycle activities	
Alert	Organise meetings with government departments and relief Agencies Facilitate visits to areas of concern Assist commercial destocking Conduct water point surveys and check state of repair of water facilities; check status of water management committees (if any) If not already in place, start weekly tracking of cereal and livestock prices Check status of veterinary services, including availability of drugs in public and private sectors, and status of Community Animal Health Workers (CAHW)

TABLE 1.1. EXAMPLE OF THE TYPE AND INTENSITY OF ACTIVITIES REQUIRED AT DIFFERENT STAGES OF A CALAMITY CYCLE

Alarm	Scale up and intensify all the above activities, plus: Intensify commercial destocking Expand livestock/cereal exchange Define strategies for livestock feed supplementation Support veterinary care as needed Rapid rehabilitation of water points; coordinate with human water supply agencies as necessary
Emergency	Scale up all of the above activities, plus: Destocking for slaughter and local meat distribution Supplementary feeding of core breeding animals
Recovery	Maintain veterinary interventions, plus: Restocking of viable pastoralist households
No drought	Drought contingency planning

Current evidence points to the cost-effectiveness of early response to drought in pastoral areas using approaches such as commercial destocking. Emergency preparedness and contingency planning activities which can support early response to emergencies in pastoralist areas include the following:

Contingency plans and triggers – all agencies should develop contingency disaster plans with clearly- defined triggers for action and the subsequent release of funds and other resources. Such plans are informed by knowledge of past crises, and the types of response which can be implemented within a given operational and funding context. It is important that contingency plans are developed with local partners and include specific, clearly defined and pre-agreed triggers for prompting action and the release of contingency funds. In the case of ruminant livestock including camels, Knowledge on body weight and body condition scoring are critical triggers for intervention as a useful tool to mitigate the damage that can be caused by drought and other related calamities.

There is no one-size-fits-all approach to livelihoods. Interventions must be adapted to the local context. Different factors fundamentally change the way livelihood interventions should be designed. This guide provides a framework for assessment to help trainers determine the right combination of interventions to arrive at a holistic approach that is well adapted to the local context.

SECTION TWO

INTERVENTIONS FOR LIVELIHOOD RESTORATION AND REHABILITATION

The objective of rehabilitation and protection should be to help the poor and vulnerable in emergency affected areas**.** The aim is to safeguard them from human capital and asset loss, enhance their access to food, and rehabilitate food production systems and livelihoods damaged or destroyed by the calamity. Activities should target poor and vulnerable households at risk of food insecurity and/or who have lost their income as a result of the locust upsurge or who have experienced damage to their livelihood assets. An added element that would be provided for livestock keepers is fodder provision to sustain livestock where grazing has been lost due to the impact of harsh climate. The interventions should promote the adoption of climate-smart crop and livestock practices for reduced GHG, enhanced resilience, and the implementation of livelihood support and diversification initiatives. Support should be provided for agroecosystem management approaches that enhance resilience of farm and landscape to changes. This should be achieved through delivering (i) climate-smart farmer packages to get food and fodder production re-started as soon as possible; (ii) pasture restoration or temporary forage/feed provision and climate-resilient grazing management in pastoralist areas negatively impacted (iii) in certain cases assisting with animal destocking and re-stocking with climate-resilient and stress tolerant breeds to mitigate the negative effects of the calamity.

This section covers five modules namely: climate change and climate variability; Natural resource management; crop production and management; livestock production and management, and range management

2.1 MODULE 1
CLIMATE CHANGE AND VARIABILITY

Introduction

Climate change (CC) and climate variability (CV) are real and are an impediment to sustainable development globally. Climate change causes a range of positive and negative impacts in agriculture depending on the regions of the world. The negative impacts are expected to be more adverse in developing countries, particularly those in sub-Saharan Africa such as Kenya which has been experiencing increasing temperatures from the 1960's coupled with increased frequency and intensity of extreme weather events such as El Niño and La Niña. Effects of the negative impacts include declining agricultural productivity; land degradation; loss of crops, livestock and fish due to changing temperatures and precipitation regimes and increased frequency and intensity of extreme weather events. The current status of climate change shows that the rise in global temperatures since the industrial revolution has been 0.75 °C. The ten (10) warmest years in the 134-year record have all occurred since 2000. Atmospheric concentrations of CO_2 have increased from 280 ppm in 1850 to 401.58 ppm.

The country's agriculture sector is predominantly rain-fed and therefore vulnerable to climate change. The sector is not only impacted upon by climate change but also contributes to the problem. It is a source of greenhouse gas (GHG) emissions; responsible for one-third of Kenya's total emissions in 2010 and it is envisaged that this is likely to increase to 27 metric tons of carbon dioxide by 2030. Apart from the threat of climatic changes, the agriculture sector is affected by increasing population pressures and demand for natural resources. In their quest to boost incomes, enhance food security, increase overall productivity and market competitiveness, agricultural households face the challenge of maintaining an efficient natural resource base.

Agricultural production systems should provide adequate food and nutritional requirements; sufficient income for farmers to sustain a comfortable standard of living; and protect ecosystems both now and for future generations, including coping with changing weather patterns. This call for climate smart agricultural practices that sustainably increases productivity; resilience or are adapted to changing climatic conditions; reduces/removes greenhouse gases; and enhances the achievement of national food security and development goals.

A climate system consists of various components and dynamics. It comprises; atmosphere, ocean, ice and snow cover, land surface and its features. Mutual interactions between these components are physical, chemical and biological processes. All these processes are explained by a complex set of equations that predict their future under modelling and downscaling.

This module discusses the following aspects:

- Weather
- Climate
- Climate Change
- Climate Variability
- Greenhouse effect
- Adaptation
- Adaptive capacity
- Carbon sink
- Resilience
- Climate information services
- Impacts of climate change and climate variability
- Climate smart agriculture
- Conservation agriculture
- Gender in Climate Smart Agriculture (CSA) and Conservation Agriculture (CA)

Weather

Weather is the summary of temperature, rainfall, wind, humidity, sunshine, cloudiness or storms patterns in a specific place on a specific day or over a short period such as a season. They also include extreme events such as tornadoes, droughts and tropical cyclones. Thus, weather are what we see/hear/feel every day in a given location, which is the state of atmospheric conditions at a particular place and time. Weather is dynamic and can change within a very short period of time, even within the same day.

Climate

Climate refers to average weather conditions (taken over a period not less than 30 years), including statistical description of its variations. Several factors contribute to the definition of climate, including long term averages of temperature and precipitation, but also the type, frequency, duration, and intensity of weather events such as heat waves, cold spells, storms, floods and droughts. Climate is a complex natural process that involves the interaction of the air, the water, and the land surface. The Earth's climate is in a state of continuous change, and has changed many times in response to various natural and human causes. The movement of air through the atmosphere and that of water through the ocean also affect temperature and rainfall.

Climate Change

Climate change (CC) refers to a broad range of alterations in climatic and weather conditions (Figure 2.1). It is characterised by changes in average conditions and in the frequency and severity of extreme conditions that have occurred over a long period of time, generally over 30-35 years. Climate change is the change in the long-term meteorological average itself, whatever the cause. The reality of CC is indisputable as it is seen or felt across the globe. It negatively impacts on core fabrics of human livelihood systems i.e. crops, livestock, water, soil, biodiversity.

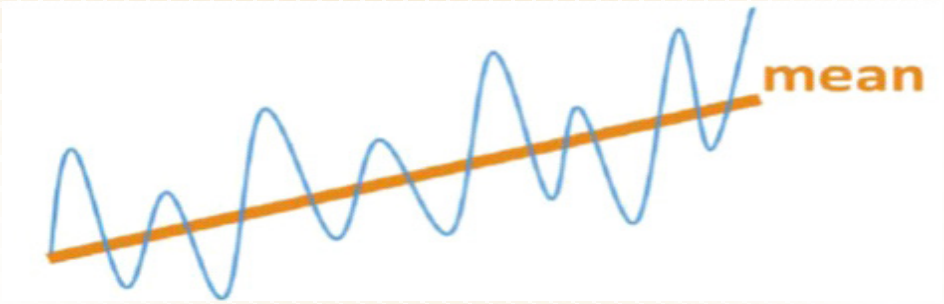


Figure 2.1. Climate change: Focuses on trend and mean changes

Climate Variability

This refers to year to year fluctuations including seasonal variations in the climate parameters. The causes of climate variability (CV) are directly or indirectly by both natural processes and human activities. These processes can increase accumulation of greenhouse gases (GHGs) in the atmosphere. CC and CV arise from the changes in the elements of the atmosphere. Several indicators of CC/CV are manifesting up to farm level. Temperatures have increased, rainfall decreased & depressed, increased pests and diseases affecting both livestock and crops that are the main livelihoods of the poor.

Greenhouse Gases

Greenhouse gases occur naturally in the atmosphere. These gases have longer wavelengths than visible light, which allows the gases to absorb and emit radiation. GHGs cause increased temperature on earth. Human activities that increase GHGs? include; Industrialization, Deforestation, Transport and Energy production. The most common greenhouse gases are:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)

- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF6)

Greenhouse Gases Effect

Greenhouses gases have chemical characteristics that allow these gases to capture, absorb and store heat energy for a long time (Figure 2.2). The greenhouse effect is therefore the process by which greenhouse gases absorb, reflected long wave radiation (background radiation), and raise atmospheric temperature

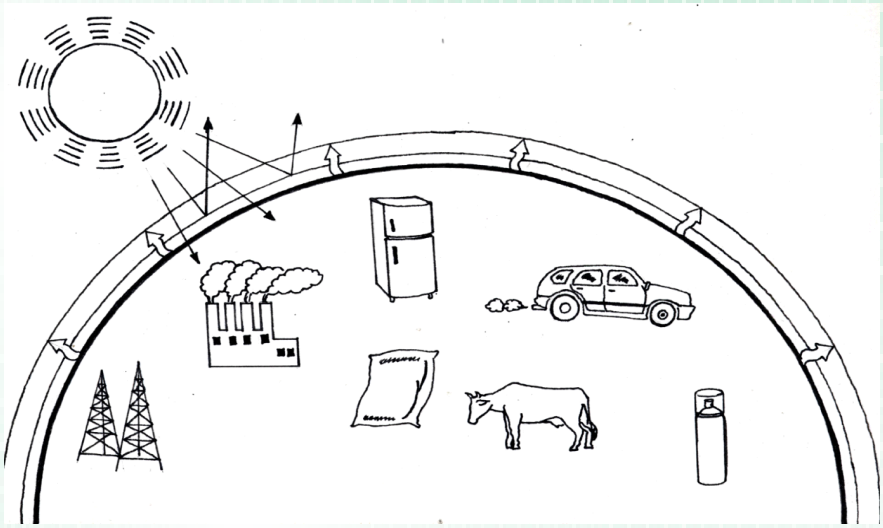


Figure 2.2. Greenhouse effect (Source Esilaba *et al.,* 2021)

Other Key Terminologies Relevant to Climate Change and Variability

Adaptive capacity - The ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Carbon sink - Any process, activity, or mechanism that removes carbon dioxide from the atmosphere. Carbon sinks include the **oceans, plants, and other organisms** that remove carbon from the atmosphere via photosynthetic processes.

Mitigation - A human intervention to reduce the human impact on the climate system, including strategies to reduce greenhouse gas (GHG) sources and emissions and to enhance GHG sinks.

Resilience - The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change.

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

2.1.1 SUB-MODULE 1: CLIMATE INFORMATION SERVICES

Climate Information is the data or knowledge about past, present and future climate conditions. Its interest is in understanding the implications of this information on development, people's livelihoods and the environment. It provides information relevant for designing and mainstreaming adaptation measures. It facilitates adaptation planning for short, mid or long-term. It also helps in facilitating early warning systems on climate issues.

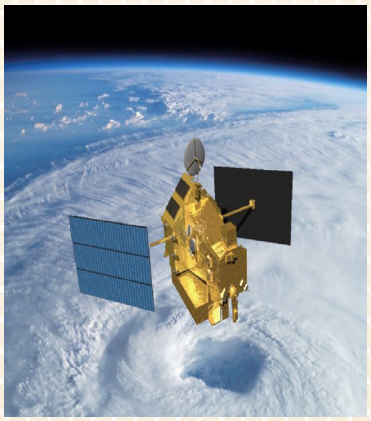
Types of Climate Information

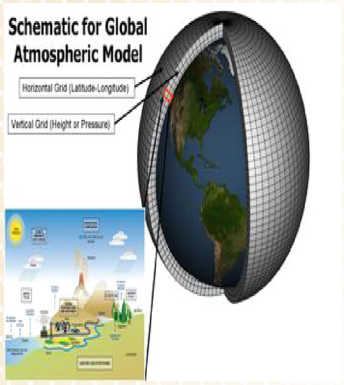
- Real time meteorological data - describes present weather
- Historical meteorological data - describes historical climates

- Future weather/climate - short/medium range weather forecast, and long range climate predictions

They are in the scales of

- Global
- Regional climates
- Microclimate (local scales)
- Small-scale climates are referred to as microclimates





Met Station Satellite Instrument Models

They are sourced from

- Weather stations (KMS, WMO, NOAA….)
- Satellite data (Instruments such as RADAR, Infrared…..)
- Reanalysis data – Use of climate models (NCEP, NCEP2, ERA Interim……)
- The data are processed and interpreted for decision making activities such as adaptation planning

Why focus on climate information?

- Understanding climate information is critical for decision making – planning.
- Climate information can be confusing and sometimes creates conflicts.
- Impacts of climate change (and related adaptation measures) can be obtained from climate information (i.e. scenarios of the future climate).
- CC and CV places significant stress to food production and availability.
- Growing demand for food and energy places additional pressure on the food systems and the natural resources.
- Building resilience to climatic shocks requires clear climate information.
- Decision-making use information for short, medium, and long-term adaptation measures.
- Therefore, there is need to improve the availability, quality and use of climate information.
- There is a growing demand by stakeholders for better climate information.

Communicating climate information – issues to consider

- Communication channels between producers and users - accessible, effective, timely and bidirectional.
- Communication language, style and channel - consider social roles, inequalities, levels of literacy, numeracy, and fluency in a given language.
- Packaging of climate information -tailored to specific users 'capacities and needs.
- Style and visual packaging - contribute to understanding, even by those who are not literate.
- Communications systems – take note of the systems that already exist at local level.
- Information access and use - determine gender access and use rights of information in the specific communities.

Contribution of climate services to Climate Smart Agriculture

Comprises of productivity, adaptation and mitigation;

Productivity.

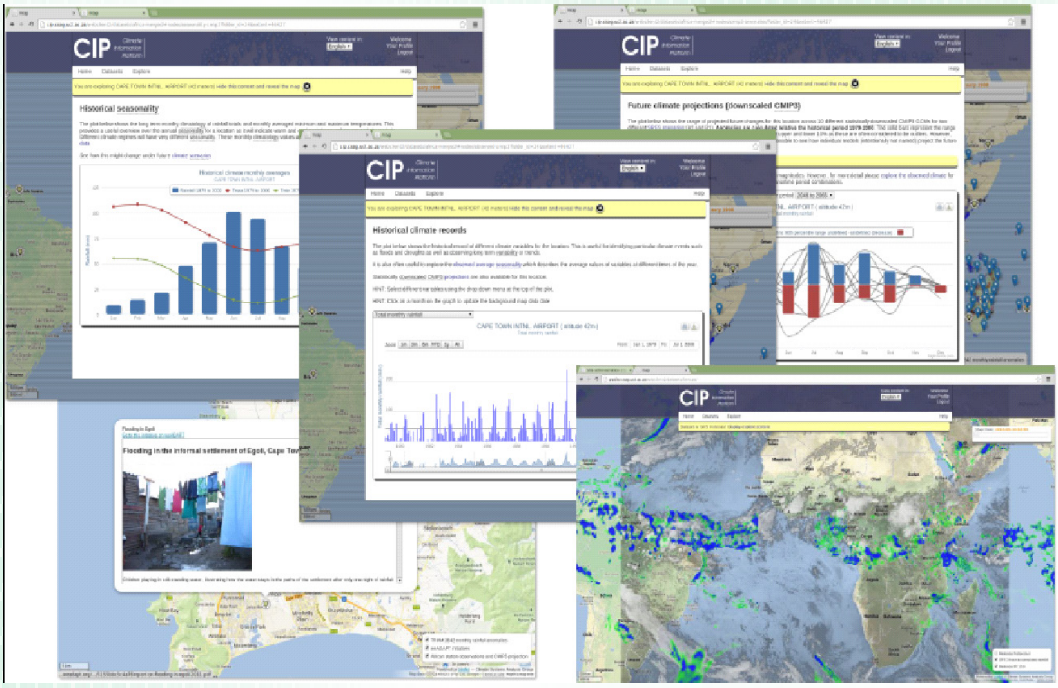
- Adequate and timely info - increase productivity.
- It's a basis for planning.
- It supports decision-making; options to invest in, when and how much.

Adaptation through risk management

- Enables farmers to manage the negative impacts of weather-related risks in poor seasons better, while also taking greater advantage of average and better than average seasons.
- Flexibility to switch from one strategy to another or to combine strategies - adjust their plans as climate stressors and shocks unfold.

Mitigation

- Information supports efficient use of fertilizers - reducing emissions of GHG.
- There is increased demand & sources for Climate information globally.



Climate Information Platform

Direct effects

- Complete crop failure from delayed rains or limited rains or rainfall failure
- Reduction of crop and livestock yield.
- Decreasing availability of water for crop production and drinking and livestock use, drying of water sources.
- Increasing frequency of droughts leading to crop failures, loss of pastures, loss of livestock and livestock feed supplies.
- Occurrence of frost and abrupt cold temperatures affects crop in various counties.
- Loss of property and sources of livelihood from extreme weather events such as flash flood, windstorm, hailstorms and landslides.
- Insurgences of new pest and diseases in crops such as the Rice Blast Disease, Grey Leaf Spot of Maize and fall armyworm and prevalence livestock diseases and parasites.

- Loss of seeds and planting materials for next season planting.
- Land degradation and loss of soil fertility due to erosion of topsoil and runoff sparked by incessant rainfall.
- Damages to key infrastructures like bridges disconnect people from far flung remote areas making them highly vulnerable to food insecurity.
- Overall degradation of natural resources.
- Loss of agro-biodiversity and disruption of traditional seed systems.

Indirect effects

- Increased crop failures and livestock deaths will lead to decreased domestic food production resulting in the increased imports of food.
- Increase in prices of essential commodities will drive poor farmers to further poverty.
- Increased incidence of pest and diseases on humans and animals affect their health.
- Increased drudgery and workload on rural women due to declining access and degradation of natural resources.
- Disruption of the local seed system puts pressure on women who take the lead role in seed saving, seed selection and conservation of crop and varieties.
- Increased rural- urban migration and fallowing of agricultural land.
- Crop failures causes increased workload on women who are the caregivers and responsible for feeding the family.
- Reduced agricultural productivity implies lost economic opportunities at the household level and nationally.

The negative impacts of climate change and climate variability on agricultural production, can be avoided through using appropriate adaptation measures which includes improved weather and early warning systems, risk management approaches and the Climate Smart and Conservation Agriculture (CS and CA) technologies and management practices.

2.1.2 SUB-MODULE 2: CLIMATE SMART AND CONSERVATION AGRICULTURE AS A RESPONSE TO CLIMATE CHANGE AND CLIMATE VIABILITY

Rain-fed agricultural production is heavily dependent on the amount and timing of rainfall, which in many areas is highly variable. On the other hand, small scale farming faces the challenge of increasing production and preservation of the natural resources at the same time. CV and change increases already existing agricultural problems and risks. The year-to year variability of rainfall is a significant limitation to the sustainability of rain-fed farming systems. Thus, there is a need for CSA and CA agriculture practices to adapt to CC and CV.

Climate Smart Agriculture

This is defined as an approach for changing and shaping agricultural development differently under the new realities of climate change. Agriculture that increases productivity, enhances resilience (adaptation), reduces/ removes GHGs (mitigation), and achieves national food security and development goals in a sustainable way. This definition identifies the main goal of CSA as food security and development; while productivity, adaptation, and mitigation are identified as the other three interlinked pillars necessary for achieving this goal.

There are several reasons that call for the quick change of the present agricultural production system to a more climate-smart and resilient production system in these times of Climate Change and climate-related problems. The following are the six important reasons:

- The demand for food is increasing and thus more food has to be produced with the same amount of resources such as the land, water and capital.
- There is an overall reduction and degradation of natural resources that sustains agriculture production.
- Subsistence farmers are highly vulnerable to the impacts of Climate Change and there is an immediate need to adopt a more sustainable approach for adaptation to Climate Change.

- There is a need for enhancing food security while lowering effects of Climate Change and reducing destruction of the natural resource base.
- With the dangers brought about by Climate Change the agricultural production systems have to be more productive, efficient, predictable, stable in their outputs and more resilient to risks, shocks and long-term climate variability.
- Awareness and understanding of the farming communities on the potential impacts of Climate Change on agriculture is low and must be quickly increased to build their capacity for adaptation.

Climate Smart Agriculture (CSA) is anchored on 3 pillars: productivity, adaptation and mitigation:

- **Productivity:** CSA aims to increase agricultural production and incomes while eliminating negative impacts on the environment. Resulting from this effort, there is an increase in food and nutritional security in a sustainable way.
- **Adaptation:** CSA targets to reduce the exposure of farmers to risks while also strengthening their flexibility by building their capacity to adjust and grow when they encounter shocks and long-term stresses.
- **Mitigation:** CSA works to lower GHG emissions. As a result of this there are reduced emissions in production processes. We also lower deforestation from agriculture as soils and trees are managed to regulate carbon dioxide from the atmosphere.

Characteristic Approaches of Climate Smart Agriculture

- It chooses multiple technologies, innovation and management practices that work at the farm level to give the desirable level of production.
- It deals with climate change through taking note of its impacts in planning and developing agricultural systems for adoption.
- It adopts the environmental conservation that is supportive of agricultural production.
- It incorporates multiple goals i.e. increase in productivity, higher resilience and lower GHG emissions into planning.
- It takes into account impacts of climate change on gender and engages different stakeholders to identify the most appropriate interventions.
- It being context specific, it employs different interventions for different landscapes. In doing so, it handles each landscape in a unique way.

The CSA is framed and put forth as the concept for sustainable agricultural development for food security under Climate Change, but its core comprises sustainable farm based agricultural land management practices. These CSA Practices include; conservation agriculture; water harvesting, conservation measures, integrated soil fertility management and agroforestry (Module two), integrated crop management (Module three) and agricultural insurance (Module four under section three) of this manual.

Conservation Agriculture

The CA is a method of farming that conserves, improves and uses natural resources more efficiently through sustainable intensification (integration) of locally available resources. The system contributes to environmental conservation as well as to enhancement of and sustained agricultural production. It can also be referred to as resource efficient agriculture. Conventional agriculture involves intensive tillage and has been claimed to cause soil degradation, particularly when practised in areas of marginal productivity. The goal of CA is therefore to maintain and improve yields and resilience against crop water stress while stimulating biological functioning of the soil environment. CA operatives on three principles or pillars namely: Minimum soil disturbance; Permanent soil cover and crop diversification. /crop rotation and intercropping.

Minimum Soil Disturbance

The farmer tills the soil as little as possible or disturbs the soils as little as possible. The soil should only be dug where the seed, fertiliser and manure are to be placed

Minimum soil disturbance

Permanent Soil Cover

Crop residues, cover crops, tree biomass provides soil cover, or even biomass produced ex-situ. Cover crops can be intercropped with the main crop to serve the physical attributes of soil cover, biological nitrogen fixation and mineralization from the N rich biomass.

Permanent soil cover

Crop Diversification

It is a farming system that allows growing several crops. This is done through embracing crop rotation or intercropping systems. It encompasses both crop rotation and intercropping. Where, crop rotation is the systematic planting of different crops in a particular order over several seasons/years in the same farm unit. The process helps maintain nutrients in the soil, reduce soil erosion, and prevents plant diseases and pests. Intercropping is a system where two or more (multiple) crops are grown (companion planting) in the same farm unit in the same season/year making use of resources or ecological processes that would otherwise not be utilised by a single crop. The practice is most common in areas where land for cultivation is limited due to high population.

Economic benefits of Conservation Agriculture

- Resource saving: Fewer inputs are required before planting. Reduced ploughing saves farmers energy, labour and time. Farmers who use tractors to plough are able to reduce their fuel use for farm operations by two-thirds. Labour savings mean more time for members of the farm family to pursue other livelihood options, interests and investments.
- Time savings: Time savings allow farmers to plant earlier, perhaps by weeks.
- Pest and disease control: Crop rotation helps break crop disease cycles.
- Reduces crop failure risks: Diversified crops offers expanded crop sales and lowers risk of no harvest.
- Improved soil water management. Improved water infiltration and reduced water loss by evaporation and

runoff. This improves yield even with small amounts of moisture. Refraining from ploughing can reduce evaporation loss by the equivalent of 20-30 mm, or between a fifth and a third.

- Reduction in labour use. In the case of animal traction, the reduction in labour when applying conservation agriculture can be as high as 86%. Time required to prepare the land using a tractor is reduced by 58% under conservation agriculture.
- Reduction in the cost of production. Overall, with equal or slightly higher yields and reduced costs, the farm income increases under conservation agriculture. Production systems that use manual labour or animal traction physical exercise of the farmer are also reduced considerably. Besides a reduction in time required for field activities, the costs for operation and maintenance are also reduced. Ploughing activities are eliminated, farmers do not need heavy machinery or tractors, resulting in lower investment or write-off costs.
- Generally, the costs for inputs are a bit higher in conservation agriculture compared to conventional tillage, due to cover crop seeds and agrochemicals.

Environmental benefits

- Soil health. A core benefit is that soil that is little disturbed develops better soil structure. Good soil structure absorbs and retains water for crops more effectively. Nutrients from crop residues enables better nutrient cycling. Crop residues physically protect soil to reduce the wind and water erosion that inevitably diminishes soils left bare by ploughing. Conservation agriculture can reduce soil erosion by up to 96%. Biological activity continues uninterrupted in largely undisturbed soil, and nutrient-rich organic matter is left to accumulate there. All these factors contribute to long-term increases in yield and productivity.
- Reduced greenhouse gas emissions and water use. Soil with higher organic matter content sequesters more carbon than does depleted soil. Reduced need for mineral fertilisers also reduces emissions.
- Cleaner surface water. Improved water infiltration into healthy soil and reduced water erosion of bare ploughing soils keeps water, soil and agricultural inputs such as fertiliser, herbicides and pesticides in the field where they are needed and desired.
- Reduced loss of genetic biodiversity. The rotation of crops and cover crops restrains the loss of genetic biodiversity, which is a consequence of mono cropping.

Agronomic Benefits

Increase in soil organic matter. The constant addition of crop residues leads to an increase of the organic matter content of the soil. Organic matter improves fertiliser use efficiency, water holding capacity, soil tilth, rooting environment and nutrient retention. The increased organic matter content together with soil cover leads to increased water holding capacity of the soil.

GENDER IN CLIMATE SMART AGRICULTURE AND CONSERVATION AGRICULTURE

The role of gender in CSA and CA are seen in the three Pillars and Principles of CSA and CA respectively.

Pillar 1. Sustainably increase agricultural productivity and incomes

- Some of the efforts to address gender in the context of this Pillar 1 include:
- Systematic gender analysis to identify any differences in men's, women's and youth's productivity.
- Resolving the challenges or constraints that women and youths experience in accessing, using, and supervising farm labour.
- Improving women's and youth's access to productive inputs and resources such as extension services; technologies, innovations and management practices.
- Improving women's and youth's use of agricultural inputs like seeds and fertilisers.
- Improving women's and youth's tenure of natural resources e.g. land.
- Participatory identification and implementation of income-generating opportunities.

Pillar 2. Adapt to and build resilience to climate change

The impacts of CC and related adaptive strategies are not gender-neutral because vulnerability is often determined by socio-economic factors, livelihoods, people's capacity and access to knowledge, information, services and support – all of which may differ along lines of gender. In addition, men, women and youth may have different coping strategies.

As resilience-enhancing practices and approaches are developed, it is critical that climate information is made available and accessible to men, women and youth (boys and girls), and that any potential increase in workload is minimised.

Pillar 3. Reduce and/or remove greenhouse gas emissions, where possible

When pursuing practices that contribute to CC mitigation, it is good to note that women, men and youth are often in different starting positions to take them up. For example, agroforestry may be less accessible or offer fewer incentives to those with weaker land tenure rights, and soil and water conservation may be difficult if hiring labour is not possible. On the other hand, some practices, like improved cooking stoves, biomass for energy and biogas, may be more attractive to women for their labour-saving features. Proposed mitigation actions therefore should harness the experiences, expertise, and realities of women and men alike.

Further Reading

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2.2 MODULE 2

NATURAL RESOURCES MANAGEMENT

Natural resources management (NRM) refers to the management of resources such as land, trees, water, and air to ensure their continued availability for current and future generations. Natural resource management involves interactions between people and natural landscapes with their associated ecologies.

Integrated natural resource management and Community-based natural resource management technologies will be used for restoring and rehabilitation of agricultural landscapes as well as for improving livelihoods. Integrated Natural Resources Management (INRM) is an approach that integrates research of different types of natural resources into stakeholder-driven processes of adaptive management and innovation to improve livelihoods, agro- ecosystem resilience, agricultural productivity and environmental services at community, eco-regional and global scales of intervention and impact. INRM has emerged as a necessary approach to solve problems of agricultural communities.

Community-based NRM refers to the process of involving local communities in the management of these resources with the objective of both conserving the environment but also ensuring socio-economic development of local communities.

This training manual seeks to equip trainers, working in a rural context with information and skills to carry out activities related to INRM for the benefits of the targeted community. These activities range from raising awareness about natural resource depletion, facilitating discussions surrounding equitable use of natural resources, to approaching government and other agencies to ensure that local communities benefit from resources use in the areas. The training will cover the following sub-modules:

- Land degradation and sustainable agriculture
- Integrated soil fertility and water management
- Soil and water management
- Problematic soils and their management
- Irrigation and drainage
- Agroforestry systems

2.2.1 SUB-MODULE 1: LAND DEGRADATION AND SUSTAINABLE AGRICULTURE

Introduction

Degraded land is defined as land characterized by persistent decline or loss in biodiversity and ecosystem functions and services that cannot fully recover unaided within decadal time scales. Restoring degraded land can include many different types of practices that ultimately restore ecosystem function. Some examples include implementing soil water conservation practices, planting the right tree in the right place, increasing above and below ground biodiversity, conservation of natural vegetation, among many others. The Global Land Outlook highlights that land restoration has multiple benefits, including "reversing past land and ecosystem degradation while creating opportunities that improve livelihoods and prepare us for future challenges. Degradation of semi-natural and natural lands has received heightened attention as a global policy problem. Recent advances in supporting farmer innovation to restore land have been illustrated in a five-step guide for applying the options by context approach to land restoration at the World Agroforestry Centre (ICRAF).

This section presents an overview of soil degradation and sustainable agriculture.

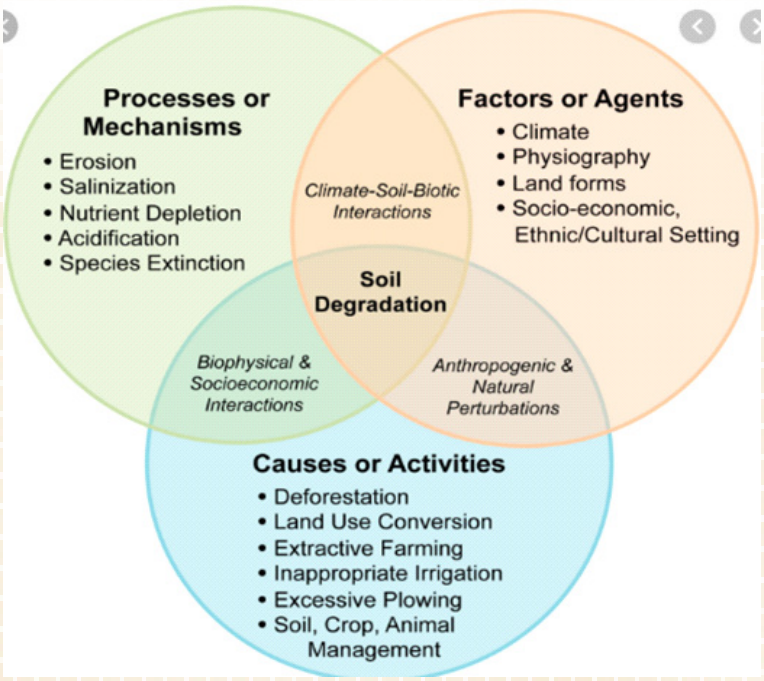

Figure 2.3. Soil degradation

Soil Degradation and Sustainable Agriculture

Soil degradation is the temporary or permanent lowering of the productive capacity of soil due to overgrazing, deforestation, inappropriate agricultural practices, over exploitation of fuel wood leading to desertification and other man-induced activities. All processes of soil degradation are grouped into six classes:

- Water erosion
- Wind erosion
- Soil fertility decline
- Salinization
- Waterlogging
- Lowering of the water table.

Gulley Erosion

Water logging

2.2.2 SUB-MODULE 2: INTEGRATED SOIL FERTILITY AND WATER MANAGEMENT

Soil management is the application of operations and practices that enhance soil health and performance. These practices may be broadly classified as soil fertility management by application of fertilisers, adoption of practices that enhance maximum soil moisture retention and minimum plant nutrient losses or losses of soil biodiversity.

Sustainable soil management is fundamental to effective soil function, particularly in intensive production systems where optimal plant growth is required to deliver maximal crop yield and quality. In intensive cropping systems, when sustainable soil management is not practised, soil structural degradation in all forms is widespread and pervasive.

Stakeholders in a maize variety and soil fertility demonstration trial at KALRO-Kakamega

Soil Fertility Management

Soil Fertility Management (SFM) strategies centre on the combined use of mineral fertilisers, locally available soil amendments and organic matter to replenish lost soil nutrients. They include Integrated Soil Fertility Management (ISFM) which involves a set of agricultural practices and germplasm adapted to local conditions to maximise the efficiency of nutrient and water use and improve agricultural productivity. ISFM is defined as 'A set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs, and improved germplasm combined with the knowledge on how to adapt these practices to local conditions, aiming at maximizing agronomic use efficiency of the applied nutrients and improving crop productivity. ISFM strategies are anchored on the combined

use of mineral fertilisers and locally available soil amendments (such as lime and phosphate rock) and organic matter (crop residues, compost, and green manure) to replace lost soil nutrients. This improves both soil quality and the efficiency of fertilisers and other agro inputs. ISFM also promotes improved germplasm, agroforestry, and the use of crop rotation and/or intercropping with legumes (a crop which also improves soil fertility).

Integrated soil fertility management demonstration trials at KALRO-Kabete

Fertilisers

A fertilizer is any material (organic or inorganic) of natural or synthetic origin that is applied to soils or to plant tissues to supply one or more plant nutrients essential to the growth of plants. However, liming materials are not considered as fertilizers. Many sources of fertilizer exist, both natural and industrially produced. Fertilizers enhance the growth of plants. Fertilisers supplement plants with the vital nutrients needed for optimal, healthy growth. There exist two major categories of fertilisers: organic and inorganic. Organic fertilisers are derived from naturally occurring substances, such as plant or animal by-products and mineral rock, but inorganic fertilisers are synthetically manufactured. Organic fertilisers undergo little processing and include ingredients such as composts and manure, while inorganic fertilisers are synthetic and typically made from petroleum.

Organic Fertilisers

The cementing agent that binds the soil particles together is the organic matter, which is found in organic fertilisers. It is both of animal and plant origin. Besides adding necessary nutrients to soil, organic fertilisers boost soil fertility status by improving all soil physical, chemical, and biological properties which most plants rely on for healthy growth and development. They play the following roles in the soils:

- Improves soil temperature regulation
- Improves soil aeration and reduces soil compaction.
- Improve infiltration rate
- Improves soil organisms' population
- Improves soil water and nutrient holding capacity.

Practices that increase organic matter in the soils include crop rotations that contains high plants residues, leaving crop residues in the field, growing cover crops, use of low or no tillage systems, mulching, growing perennial forage crops, using optimum nutrient and water management strategies for healthy plants production with large number of residues and roots, growing cover crops and application of compost or manure.

Apart from in situ organic matter accumulation, there exists a wide range of locally available organic amendments. They include farmyard manure, green manure, compost manure, sewage/sludge, and marine by-products.

Farmyard Manure

Farmyard manure is made from livestock animals such as cattle, chickens, horses and sheep waste and their beddings. The amount of nutrient that manure provides and its subsequent availability to plants is influenced by a several factors:

- Nutrient content of the animal feed
- Storage and handling procedures of the manure
- Amount and type of materials added to the manure
- Timing and method of application
- Properties of the soil
- Choice of crop.

Legume /green manure

Green manure is made from crops that are generally grown for less than a growing season and are ploughed and incorporated in the soil before producing seeds. Examples of common green manure crops are annual ryegrass, Sudan grass, tithonia and sesbania. Legumes are particularly beneficial since they are nitrogen fixing species and are a good source of nitrogen. A particular advantage of implementing a legume/green manure rotation into the soil/cropping system is the added source of organic matter. Green manures also improve soil structure by reducing bulk density.

Sewage Sludge

Sewage sludge consists of the solid products formed during sewage treatment. It is not uniform in mineral composition but generally, it contains between 1 to 3% total nitrogen

Compost

Composting is the controlled biological and chemical decomposition and conversion of animal and plant wastes with the aim of producing humus. Humus is the dark organic material in soils, produced by the decomposition of vegetable or animal matter and is essential to the fertility of the soil.

Compost functions as a form of organic fertiliser made from leaves, weeds, manure, household waste and other organic materials, thus it can reduce the cost of fertiliser from other sources**.**

- Proper compost management leads to an increased proportion of humid substances in the soil due to high micro-organic activity, and therefore applying compost leads to quantitative and qualitative improvements of the humus content of the soil, which leads to an increase in crop yields.
- Composting helps to improve soil fertility which is helpful in reducing the impacts of climate change.
- Composting helps increase soil moisture and soil cover, as well as reduce soil loss.
- Compost is made from decomposed plant matter such as vegetable peels, eggshells, coffee grounds and other organic scraps. Regardless of the source, compost provides soil with a well-balanced mix of nutrients, including nitrogen, phosphorus, and potassium.

Manure

Manure management activities involve the handling of animal dung and urine (farmyard manure) predominantly in the solid form when applying it to croplands**.**

Applications of manure in the croplands enable achieving and maintaining a fertile soil, which can increase crop yields.

The application of manure can improve productivity and produce greater crop yield which is important for adapting to climate change.

Manure comes from livestock animals such as cattle, chickens, horses and sheep, although bat and bird guano are also effective organic fertilisers. Like compost, manure also does double duty by adding essential nutrients to the soil as

well as improving soil quality and its water-retention ability. Because manure can cause food-borne illness, use either composted manures or apply fresh manure well in advance.

Marine by Products

Fish emulsion, fish scrap and seaweed extracts are important sources of soil nitrogen, phosphorus, and potassium. Fish emulsion, which is derived from partially decomposed ground fish, is an organic fertiliser that provides high levels of nitrogen to soil. Fish scrap is another marine byproduct and organic fertiliser that contains both nitrogen and phosphorus. Seaweed extracts provide nitrogen and potassium as well as trace elements to soil and have a less intense odour than the fish derivatives.

Meals

Meal supplements are agricultural byproducts from the meat and farming industries. Common examples of meals used as organic fertilisers include blood meal, which provides high levels of nitrogen and iron; bone meal, which is rich in both nitrogen and particularly phosphorus; and cottonseed meal, which contains all three macronutrients – nitrogen, phosphorus and potassium.

Rock Minerals

Although mined rock minerals differ from other organic fertilisers in that they are not derived from a previously living organism, they are still considered organic fertilisers because they have not undergone extensive processing and provide soil with nutrients vital to healthy plant growth and development. Common examples of mined rock mineral fertilisers include rock phosphate, greensand, and sulphate of potash magnesia.

Mulch

Mulching is the process of covering the soil surface with organic matter to create conditions that are more favourable for plant growth (i.e., creating an optimal climate independent of weather conditions), improving the decomposition and mineralization of organic material in the soil (i.e., surface composting), and protecting the soil from erosion.

Mulching can improve the productivity of the land (i.e., crop yields) by making conditions more favourable for plant growth, i.e., conserving soil moisture, improving soil fertility and reducing soil erosion.

This can be derived from organic or inorganic materials. Organic mulch improves soil fertility through decomposition of the materials. Examples of organic mulches include grass clippings, shredded leaves and old hay. Annual applications of mulch, along with compost, improve soil's ability to absorb nitrogen and other nutrients. Inorganic mulch contributes to soil fertility management through soil moisture retention and regulation of soil environment making it suitable for micro-organism action.

Improved Fallow

The planting of fast-growing species of leguminous trees or crops into a short-term fallow for one or more years to improve soil fertility.

Improved fallows help restore fertility to land whose nutrients are depleted. Plant species like grasses or legumes that fix nitrogen grow during the fallow period. As the nitrogen fixing plants grow, excess nitrogen is released back into the soil. Nitrogen is a vital nutrient for plants and plant growth. Planting nitrogen fixing plants is very important for rebuilding soil fertility and improving crop yields.

- Improved fallows can help restore degraded land which can be important for adapting to climate change.
- They also can help to protect the soil from excessive heat, exposure to wind, and moisture loss.
- Improved fallows require less fertiliser and therefore have fewer greenhouse gas emissions.
- The leaves of the leguminous plants can be incorporated into the soil, increasing the carbon in the soil.

Plant leguminous shrubs, such as Sesbania, Tephrosia, Crotalaria and Cajanus, in fallow lands. These plants are better than natural fallows for enhancing soil fertility, especially for restoring nitrogen and improving other soil properties, and they ease the work of tilling the soil.

Inorganic Fertilisers

Inorganic fertilisers come in single-nutrient or multi-nutrient formulas. Multi-nutrient formulas include compound and single fertilisers, which contain basic nutrients, such as nitrogen, phosphorus, and potassium, as well as secondary and micronutrients such as calcium, magnesium, boron and manganese. The percentage of nitrogen, phosphorus and potassium contained in both complete and balanced fertilisers is indicated by three numbers on the package. For example, a 5-10-5 formula is a compound fertiliser, containing 5 percent nitrogen, 10 percent phosphorus and 5 percent potassium. Balanced fertilisers are those that contain equal nutrient amounts, such as a 10-10-10 formula.

Inorganic fertilisers include slow-release formulas. These formulas contain larger molecules that are coated, helping them to break down slowly in the soil. A typical slow-release fertiliser releases nutrients over a period of 50 days to a year, reducing the chance of burning the plant or root system. Specially formulated inorganic fertilisers are those that are created for a specific type of plant. Specially formulated fertilisers are usually highly acidic and should be used only on the plants for which they are indicated.

Nitrogen Fertilisers

Inorganic nitrogen fertilisers come in many different forms, such as ammonium nitrate, potassium nitrate, calcium nitrate and urea. These fertilisers contain high levels of nitrogen, one of the most vital nutrients for plant growth. However, these inorganic fertilisers tend to increase the pH of the soil upon application, increasing the chances of burn and damage to seedlings. Others pull moisture from the air, making them difficult to apply and store.

Phosphorus Fertilisers

Inorganic phosphorus fertilisers such as Superphosphates (single superphosphate, triple superphosphate) are forms of phosphorus fertiliser. These do not affect the pH of the soil upon application, while ammonium phosphates (Di-ammonium phosphate (DAP) and Mono ammonium phosphate (MAP)) come in water-soluble, granular forms.

Potassium Fertilisers

Inorganic potassium fertilisers include potassium sulphate and potassium nitrate, as well as muriate of potash, also known as potassium chloride. Muriate of potash is the most commonly used potassium fertiliser. In some cases, plants may be sensitive to chloride. If a plant is sensitive to chloride, potassium sulphate, also known as sulphate of potash, is a better choice, as it does not contain chloride. Potassium nitrate is easy to apply, because it does not pull moisture from the air, but it does slightly increase the pH of the soil upon application.

Fertiliser Application Methods

The method of applying fertilisers depends on the nature of crops, their nutrient needs, and the soil.

Broadcast

Fertiliser is spread on the soil surface. It precedes tillage so that the fertiliser can be mixed with the soil this results in uniform fertiliser applications. Both fluid and pellet fertiliser may be broadcast. This provides the most uniform distribution of nutrients within a given soil volume. This method is suited particularly well to high rates of applied fertiliser. It is inefficient and may be wasteful.

Broadcasting of fertilisers is carried out at time of planting and during crop growth.

At time of planting depending on the crop, broadcasting of the fertiliser is carried out prior to sowing/planting or just before the last ploughing and incorporated in the field. Broadcasting of fertilisers at the time of planting is generally done under conditions:

- When the soils are highly deficient in nitrogen and
- When the previous crop has been exhaustive such as sugarcane, maize, etc.

During Crop Growth Period, broadcasting in standing crop is done mainly for nitrogenous fertilisers and mostly for close spaced crops like paddy rice and wheat. It is called top dressing. Muriate of potash is also applied as top dressing in some crops, but this is not a general practice.

Banding

Fertiliser is placed in a continuous band at the bottom of the furrow opened during ploughing. Each band is covered with soil after the application. In single band placement fertiliser is applied on one side of the planted row. Band applications of fertiliser concentrate nutrients within a specific soil volume. The goal of band applications is to limit the contact of the applied fertiliser with the soil. This application method is desirable when fertiliser reacts with soil to produce compounds that reduce its availability to the crop. It is an efficient way of supplying plants with nutrients.

Drill Application

Drill application refers to the drilling of fertiliser at sowing time. Drilling the fertiliser together with seed should be avoided as it may adversely affect the germination, or the young plants may get damaged due to high or concentration of chemicals in the root zone. It is advisable to use a separate attachment for seed and fertiliser drilling. This is one of the best methods for applying phosphatic (P) and potassium (K) fertilisers to closely spaced row planted crops like wheat, maize, etc. This method is also better for applying nitrogenous fertilisers. However, it is safer to drill only small quantities of fertilisers so that germination may not be adversely affected. Foliar Application

Foliar application refers to the spraying of fertilizer solution on foliage (leaves) of growing plants. Normally, these solutions are prepared in low concentration (2-3%) either to supply anyone plant nutrients or a combination of nutrients. It is the most suitable form of topdressing when there is inadequate soil moisture.

Starter Solutions

The use of liquid fertilisers as a means of fertilisation has assumed considerable importance in foreign countries. Solutions of fertilisers, generally consisting of N, P2O5, and K2O in the ratio of 1: 2: 1 and 1:1:2 are applied to young vegetable plants at the time of transplanting.

These solutions are known as ‘Starter Solutions’. They are used in place of the watering that is usually given to help the plants to establish. Only a small amount of fertiliser is applied as a starter solution.

Irrigation Water/Fertigation

Fertilisers are allowed to dissolve in the irrigation stream. The nutrients are thus carried into the soil in solution. This saves the application cost and allows the utilisation of relatively inexpensive water.

Fertigation

Fertigation is the technique of supplying dissolved fertilisers to crops through an irrigation system. Intensification of agriculture by irrigation and enhanced use of fertilisers may generate pollution by increased levels of nutrients in underground and surface waters. Therefore, judicious management of plant nutrients available through different fertilisers need to be catered. A higher efficiency is possible with the help of a pressurised irrigation system that is placed around the plant roots uniformly and allows for rapid uptake of nutrients by plants. Small application of soluble nutrients saves labour, reduces compaction in the field and thereby enhances productivity.

Inorganic Fertilisers vs. Organic Fertiliser

Both organic and inorganic fertilisers provide plants with the nutrients needed to grow healthy and strong (Table 2.1). However, each contains different ingredients and supplies these nutrients in different ways. Organic fertilisers work overtime to create a healthy growing environment, while inorganic fertilisers provide rapid nutrition. Determining which is better for crops depends largely on the needs of the crops and preferences of the farmer in terms of cost and environmental impact. Organic fertilisers are environmentally friendly. Overuse of Inorganic fertilisers cause pollution of groundwater, stripping of soil nutrients, and plant and root burn if utilised improperly. The continual use of inorganic fertilisers reduces the soil’s resistance to pests and diseases killing off the natural microbial activity.

TABLE 2.1. COMPARISON OF ORGANIC AND INORGANIC FERTILISERS

	Organic	Inorganic
Composition	--Contain only plant- or animal-based materials that are either a byproduct or end product of naturally occurring processes Low in soil nutrients	-Mineral processed fertiliser -Supplement the soil with macronutrients needed in large amounts: nitrogen, phosphorus and potassium
Nutrient Availability	-Rely on soil organisms to break down organic matter -Release nutrients only when the soil is warm and moist -Nutrients are released slowly -Reduces the risk of nutrient leaching	-Provide this nutrition in plant-ready form -Nutrients may leach deeply into the soil and water table
Application	-Bulk application -Analysis needed to determine the amount of nutrients being applied	-Application is simple, easily mechanised -amount of a given element -Rate of application can be easily calculated -Expensive
Cost/availability	Locally available and relatively cheap	-Expensive
Environmental Impacts	-Organic materials are able to fully decompose. -Lower release of greenhouse gas	-Heavy applications can burn crop -Build up toxic salt concentrations in the soil, which can create chemical imbalances -High release of greenhouse gas

Assessment of Soil Health: Tools for assessment

Soil health assessment involves processes where many potential indicators are evaluated for their use in standardised, rapid, quantitative assessment of soil health based on relevance to key soil processes, response to management, and complexity of measurement.

Soil assessment or testing starts with the correct procedure of taking soil samples using appropriate tools. Soil sampling is a systematic collection of soil samples in a farm for analysis.

Soil analysis is the chemical, physical or microbial technique that estimates the availability of nutrients, particles, and organisms in the soil for plant growth. Soil contamination and presence of toxic elements is also done through soil analysis. The basic soil test involves the determination of components that are of significance to crop growth such as pH, phosphorus, calcium, potassium, magnesium, sodium, cation exchange capacity, base saturation, and bulk density.

The test methods used in nutrient determination in soils and plant tissue correlate the relationships between the quantity and mineral form of the essential elements present in the soil and plant. This enables the land user to know what is needed to ensure the condition of the soil is suitable for the crop to reach its genetic yield potential. The soil and plant tissue tests are the most reliable method for identifying and confirming the nutrient deficiencies.

Soil sampling at KALRO-Kabete

Steps of Soil Sampling

- Remove debris from the ground surface at the point where the sampling is to be done.
- Use an auger to dig a small hole about 20cm deep (topsoil sample).
- Place into a clean container.
- Optional - At each of the 10 sub-sample locations, collect soil hardness information with a penetrometer.
- Record maximum hardness (in psi) from the 0-6" and at the 6-18" depth ranges on the Submission Form.
- Repeat steps A – D to collect the remainder of the sub-samples. Mix thoroughly and transfer 3-6 cups of soil into a clearly labelled re-closable freezer bag. The amount of soil required depends on the analysis package selected.

Importance of Soil Sampling and Testing

- To establish baseline soil nutrient status.
- To measure changes in soil nutrient status over time.
- To assess the overall nutrient status of different soil types essential for crop growth and development.
- To predict nutrient deficiencies in current or succeeding crops.
- Establish fertiliser application recommendations (types and rates). This helps to avoid excessive nutrient application or accumulation of soluble salts.
- To assess nutrients removed in crop residues.
- To monitor the soil pH (acidity and alkalinity) and organic matter content.
- For soil biological characterization.
- For soil physical characteristic evaluation (soil physical characteristics are crucial determinants of the plant rooting pattern).

What to Consider When Undertaking Soil Sampling

When carrying out soil sampling, it is important to ensure that the samples are representative of the whole farm, portion of the farm or the locality being mapped out. It is important to always take separate soil samples where farm features differ because they have an effect on soil fertility. Features associated with soil fertility variability in the farm include:

- Topography (slope length or gradient, rocky outcrops).
- Soil types (texture, colour).
- Land degradation intensities (erosion sites, vegetation cover and type).
- Land-use history (past land use, cropping systems and fertility inputs applied)
- Current land use, - including farm structures, trees/crop(s) grown and soil conservation measures in place
- Distance from the roads (paths), homestead and livestock facilities.

2.2.3 SUB-MODULE 3: SOIL AND WATER MANAGEMENT

Conservation of soil and water resources is important for the sustainability of agriculture and the environment. The concept of soil conservation cannot be materialized without conserving and efficient use of water resources. Soil and water conservation can be carried out through tillage management or in-situ water harvesting.

This section consists of:

- Tillage management
- In-situ water harvesting
- Rainwater Harvesting for Storage (Ex-situ water harvesting)
- Soil and Water Conservation Measures
- Future Perspectives for Soil and Water Conservation

Tillage Management

This section presents an overview of the benefits of tillage and residue management and techniques for implementing it.

Tillage is defined as the mechanical manipulation of the soil for the purpose of crop production significantly affecting the soil characteristics such as soil water conservation, soil temperature, infiltration and evapotranspiration processes. Tillage systems are sequences of operations that manipulate the soil in order to produce a crop. The ways in which these operations are implemented affect the physical and chemical properties of the soil, which in turn affect plant growth.

Tillage management is any form of conservation tillage where residue, mulch, or sod is left on the soil surface to reduce soil disturbance and decrease emissions release.

Recent studies on tillage show that conservation tillage increases soil carbon in the upper layers. This is of crucial importance for the productivity of most tropical soils.

Tillage Systems

Conservation Tillage

This is the tillage and planting system that covers 30 percent or more of the soil surface with crop residue, after planting, to reduce soil erosion by water. Where soil erosion by wind is the primary concern, conservation tillage is defined as any system that maintains at least 1,120 kilograms per hectare of flat, small grain residue equivalent on the surface throughout the critical wind erosion period. The tillage systems classified as conservation tillage are no-till, ridge-till, and mulch-till.

No-till - The soil is left undisturbed from harvest to planting except for nutrient injection. Planting or drilling is accomplished in a narrow seedbed or slot created by coulters, row cleaners, disk openers, in-row chisels, or rototillers. Weed control is accomplished primarily with herbicides. Cultivation may be used for emergency weed control.

Ridge-till - The soil is also left undisturbed from harvest to planting except for nutrient injection. Planting is completed in a seedbed prepared on ridges with sweeps, disk openers, coulters, or row cleaners. Residue is left on the surface between ridges. Weed control is accomplished with herbicides and/or cultivation. Ridges are rebuilt during cultivation.

Mulch-till - The soil is disturbed before planting and includes all conservation tillage practices other than no-till and ridge-till. Tillage tools such as chisels, field cultivators, disks, sweeps or blades are used. Weed control is accomplished with herbicides and/or cultivation. Two tillage practices that fall into this category are zone-till and strip-till. Both of these tillage practices involve tilling a strip into which seed, and fertiliser are placed. Although these are popular terms in some areas, they are not official survey categories because they are considered modifications of no-till, mulch-till or "other tillage types." Less than 25% row width disturbance is considered no-till. More than 25% row width disturbance would be considered mulch-till or "other tillage type," depending on the amount of residue left after planting.

Reduced-till - Reduced-till systems leave 15-30 percent residue cover after planting or 560 to 1,120 kilograms per hectare of small grain residue equivalent throughout the critical wind erosion period.

Conventional-till - Conventional-till systems leave less than 15 percent residue cover after planting, or less than 560 kilograms per hectare of small grain residue equivalent throughout the critical wind erosion period. These systems generally involve ploughing or some other form of intensive tillage.

There are other tillage systems that leave less than 30 percent crop residues but meet erosion control goals with or without other supporting conservation practices, such as strip cropping, contouring, terracing.

In-situ Water Harvesting

Rainwater harvesting for infiltration, also known as in-situ water harvesting, is a practice in which rainwater uptake in soils is increased through the soil surface, rooting system and groundwater. Soil effectively acts as the storage

agent, which improves water holding capacity and fertility and reduce risks of soil loss and erosion. Examples of water harvesting practices include bench terraces, 'Fanya juu' terraces, check dams, contour bunds and hedgerows, planting pits / Zai pits, Katumani pits, stone lines, trash lines, grassed waterway, retention ditches as indicated below:

Cut-off drains

Cut-off drains are made across a slope for intercepting the surface runoff and carrying it safely to an outlet such as a canal or stream. Their main purpose is the protection of cultivated land, compounds, and roads from uncontrolled runoff, and to divert water from gully heads. It serves as both soil and water conservation method.

Retention Ditches

These are made along the contours to capture and retain incoming runoff water and hold it until it seeps into the ground. They are alternate to cut-off drains when there is no channel to discharge the water nearby. Sometimes these are for water harvesting in semiarid areas.

Terracing

Terraces are constructed across the field slope for soil and water conservation purposes. They reduce soil and water through erosion from hilly or sloppy lands by collecting and storing surface runoff. Terraces also increase water retention and infiltration in the soil. They consist of channels and embankments of soil constructed along the contour. They can be constructed using stone bunds or strips of vegetation (live or dead).

Infiltration Ditches

The structure used to harvest water from roads or other sources of runoff is infiltration ditches. They comprise dug along the contour, upslope from a crop field and a ditch of 0.7-1.5m deep. Water is blocked at the other end when it is diverted from the roadside into a ditch and seeps into soil after it is being trapped.

Water-Retaining Pits

Water-retaining pits allow runoff water to seep into soil after by trapping the water. The runoff normally occurs into a series of pits which are dug into ground. Banks around the pits are made by the soil from the pit. Excessive water carries from one pit to the next by furrows. The amount of runoff determines the size of the pit and its typical size is 2 m square and 1 m deep.

Broad Beds and Furrows

The runoff water is diverted into field furrows (30 cm wide and 30 cm deep) in a broad bed and furrow system. The lower end of field furrows is blocked. The water backs up into the head furrow after the filling of one furrow and flows into the next field furrow. Crops are grown on the broad bed furrows of about 170 cm wide between the fields.

Rainwater Harvesting for Storage (Ex-Situ Rainwater Harvesting)

Rainwater harvesting for storage, also known as ex situ water harvesting, is a practice in which rainwater is collected and stored for productive use, for example drinking water, agriculture, sanitation and more. The rainwater can be directly captured in open storage systems, but can also be collected from roofs, soil surfaces or roads. The practice is important in arid and semi-arid areas that may experience extended periods without rain mixed with periods of intense precipitation.

Rooftop Water Harvesting with Above Ground Tank

A roof becomes a catchment when it is used for harvesting rainwater. Then it can be called a Roof catchment. Roofs are the most common types of catchments used for harvesting rainfall. In most cases, roof catchment systems provide water that can be used for domestic purposes. However, roof runoff harvesting is also used for agricultural purposes including micro irrigation of kitchen gardens, watering livestock, and for beekeeping projects. The tank size is dependent on the rainfall regime, the water demand and roof area available.

Water Pans

Water pans are shallow depressions (1 m to 3 m deep) constructed to collect and hold runoff water from various surfaces including from hillsides, roads, rocky areas and open rangelands.

When properly designed and with good sedimentation basins, the water collected can be used for livestock watering or to supplement the irrigation of crops.

Small Earthen Dams

When larger quantities of water are desired, earthen dams are preferred. An earthen dam is constructed either on-stream or off-stream, where there is a source of large quantities of channel flow. The dam wall is 2 - 5 m high and has a clay core and stone aprons and spillways to discharge excess runoff. Volume of water ranges from hundreds to tens of thousands of cubic metres. Earth dams can provide adequate water for irrigation projects as well as for livestock watering. Sediment traps and delivery wells may help to improve water quality but, as with water from earthen dams, it is usually not suitable for drinking without being subject to treatment. The cost implication is the limiting factor.

Sand Dams

Many seasonal rivers in the semi-arid areas of Kenya have sand. Though dry for most part of the year, these rivers flood during the rainy season. A sand dam is a wall constructed across the stream to restrict surface flow. The height of the dam wall is increased by 0.3 m after 30 floods have deposited sand to the level of the spillway. The water in the sand dam can be reserved for a long time due to low evaporative losses. The most convenient way to harvest water in a sand river is by sand.

Wells and Boreholes

In regions without notable and reliable surface water resources it is necessary to obtain water from underground sources such as wells and boreholes.

Soil and Water Conservation Measures

There are two types of measures for soil and water conservation, that is, mechanical/engineering/structural measures and biological measures. Mechanical measures are permanent and semi-permanent structures that involve terracing, bunding, trenching, check dams, gabion structures, loose/stone boulders, crib wall, etc., while biological measures are vegetative measures which involve forestry, agroforestry, horticulture, and agricultural/agronomic practices.

Biological Measures (agronomic/agricultural and agroforestry)

Contour Farming

Contour farming is one of the most used agronomic measures for soil and water conservation in hilly agro-ecosystems and sloppy lands. All the agricultural operations viz. ploughing, sowing, inter-culture, etc., are practiced along the contour line. The ridges and furrows formed across the slope build a continual series of small barriers to the flowing water which reduces the velocity of runoff and thus reduces soil erosion and nutrient loss. It conserves soil moisture in low rainfall areas due to increased infiltration rate and time of concentration, while in high rainfall areas, it reduces the soil loss. In both situations, it reduces soil erosion, conserves soil fertility and moisture, and thus improves overall crop productivity. However, the effectiveness of this practice depends upon rainfall intensity, soil type, and topography of a particular locality.

Choice of Crops

The selection of the right crop is crucial for soil and water conservation. The crop should be selected according to the intensity and critical period of rainfall, market demand, climate, and resources of the farmer. The crop with good biomass, canopy cover, and extensive root system protects the soil from the erosive impact of rainfall and creates an obstruction to runoff, and thereby reduces soil and nutrient loss. Row or tall-growing crops such as sorghum, maize, pearl millet, etc. are erosion permitting crops which expose the soil and induce the erosion process.

Whereas close growing or erosion resistant crops with dense canopy cover and vigorous root system viz. cowpea, green gram, black gram, groundnut, etc. are the most suitable crops for reducing soil erosion. To increase the crop canopy density, the seed rate should always be on the higher side.

Crop Rotation

Crop rotation is the practice of growing different types of crops in succession on the same field to get maximum profit from the least investment without impairing the soil fertility. Monocropping results in exhaustion of soil nutrients and deplete soil fertility. The inclusion of legume crops in crop rotation reduces soil erosion, restores soil fertility, and conserves soil and water. Further, the Soil incorporation of crop residue improves organic matter content, soil health, and reduces water pollution. A suitable rotation with high canopy cover crops helps in sustaining soil fertility; suppresses weed growth, decreases pests and disease infestation, increases input use efficiency, and system productivity while reducing the soil erosion.

Cover Crops

The close-growing crops having high canopy density are grown for protection of soil against erosion, known as cover crops. Legume crops have better biomass to protect soil than row crops. The effectiveness of cover crops depends on crop geometry and development of canopy for interception of raindrops which helps in reducing the exposure of soil surface for erosion. It has been reported that legumes provide better cover and better protection to land against runoff and soil loss as compared to cultivated fallow and sorghum. The most effective cover crops are cowpea, green gram, black gram, groundnut, etc.

Advantages

- Protection of soil from the erosive impact of raindrops, runoff, and wind.
- Act as an obstacle in water flow, reduce flow velocity, and thereby reduce runoff and soil loss.
- Increase soil organic matter by residue incorporation and deep root system.
- Improve nutrients availability to the component crop and succeeding crops through biological nitrogen fixation.
- Improve water quality and water holding capacity of the soil.
- Improve soil properties, suppress weed growth, and increase crop productivity.

Intercropping

Cultivation of two or more crops simultaneously in the same field with definite or alternate row pattern is known as intercropping. It may be classified as row, strip, and relay intercropping as per the crops, soil type, topography, and climatic conditions. Intercropping involves both time-based and spatial dimensions. Erosion permitting and resisting crops should be intercropped with each other. The crops should have different rooting patterns. Intercropping provides better coverage on the soil surface, reduces the direct impact of raindrops, and protects soil from erosion.

Advantages

- High total biomass production.
- Efficient utilisation of soil and water resources.
- Reduction of marketing risks due to the production of a variety of products at different periods.
- Drought conditions can be mitigated through intercropping.
- Reduce the weed population and epidemic attack of insect pests or diseases.
- It improves soil fertility.

Intercropping maize and beans

Strip Cropping

Growing alternate strips of erosion permitting and erosion resistant crops with a deep root system and high canopy density in the same field is known as strip cropping.

This practice reduces the runoff velocity and checks erosion processes and nutrients loss from the field. The erosion resistant crops protect soil from beating action of raindrops, reduces runoff velocity, and thereby increased time of concentration which results in a higher volume of soil moisture and increased crop production. Strip cropping is practised for controlling the run-off and erosion and thereby maintaining soil fertility.

Types of Strip Cropping

Contour strip cropping: The growing of alternate strips of erosion permitting and erosion resisting crops across the slopes on the contour is known as contour strip cropping. It reduces the direct beating action of raindrops on the soil surface, length of the slope, runoff flow and increases rainwater absorption into the soil profile.

- ***Field strip cropping:*** In this practice the field crops are grown in more or less parallel strips across fairly uniform slopes, but not on exact contours. It is useful on regular slopes and with soils of high infiltration rates, where contour strip cropping may not be practical.
- ***Wind strip cropping:*** It consists of the planting of tall-growing row crops (such as maize, pearl millet, and sorghum) and close or short growing crops in alternately arranged straight and long, but relatively narrow, parallel strips laid out right across the direction of the prevailing wind, regardless of the contour.
- ***Permanent or temporary buffer strip cropping:*** It is the growing of permanent strips of grasses or legume or a mixture of grass and legume in highly eroded areas or in areas that do not fit into regular rotation, i.e., steep, or highly eroded, slopes in fields under contour strip cropping. These strips are not practised in normal strip cropping and generally planted on a permanent or temporary basis.

Mulching

Mulch is any organic or non-organic material that is used to cover the soil surface to protect the soil from being eroded away, reduce evaporation, increase infiltration, regulate soil temperature, improve soil structure, and thereby conserve soil moisture. Mulching prevents the formation of hard crust after each rain. The use of blade harrows between rows or intercultural operations creates “dust mulch” on the soil surface by breaking the continuity of capillary tubes of soil moisture and reduces evaporation losses. Mulching also reduces the weed infestation along with the benefits of moisture conservation and soil fertility improvement. Hence, it can be used in high rainfall regions for decreasing soil and water loss, and in low rainfall regions for soil moisture conservation. Organic mulches improve organic matter and consecutively improve the water holding capacity, macro and micro fauna biodiversity, their activity, and fertility of the soil.

Conservation Tillage

In this practice at least 30% of soil surface should remain covered with crop residue before and after planting the next crop to reduce soil erosion and runoff, as well as other benefits such as C sequestration. This term includes reduced tillage, minimum tillage, no-till, direct drill, mulch tillage, stubble-mulch farming, trash farming, strip tillage, etc. The concept of conservation tillage is widely accepted in large scale mechanised crop production systems to reduce the erosive impact of raindrops and to conserve the soil moisture with the maintenance of soil organic carbon. Conservation tillage improves the infiltration rate and reduces runoff and evaporation losses. It also improves soil health, organic matter, soil structure, productivity, soil fertility, and nutrient cycling and reduces soil compaction.

Organic Farming

Organic farming is an agricultural production system that devoid the use of synthetic fertilisers or pesticides and includes organic sources for plant nutrient supply viz. FYM, compost, vermicompost, green manure, residue mulching, crop rotation, etc. to maintain a healthy and diverse ecosystem for improving soil properties and ensuring a sustained crop production. It is an environmentally friendly agricultural crop production system.

The maintenance of high organic matter content and continuous soil surface cover with cover crops, green manure, and residue mulch reduce the soil erosion in organic farming. It leads to the addition of a large quantity of organic manures which enhances water infiltration through improved bio-physico-chemical properties of soil, and eventually reduces soil erodibility. Organic materials improve soil structure through the development of soil binding agents (e.g. polysaccharides) and stabilising and strengthening aggregates which reduce the disintegration of soil particles and thus reduced soil erosion. Soil erosion rates from soils under organic farming can be 30–140% lower than those from conventional farming.

Land Configuration Techniques

Adoption of appropriate land configuration and planting techniques according to crops, cropping systems, soil type, topography, rainfall, etc. help in better crop establishment, intercultural operations, reduce runoff, soil and nutrient loss, conserve water, efficient utilisation of resources and result in higher productivity and profitability. Ridge and furrow raised bed and furrow, broad bed and furrow, and ridding the land between the rows are important land configuration techniques.

i. Ridge and furrow system: Raising rainy season crops on ridges and rabi season crops in furrows reduces the soil crusting and ensures good crop stand over sowing on flat beds. Moreover, inter-row rainwater can be drained out properly during the monsoon period and collected in farm ponds, for life-saving irrigations and profile recharging for the establishment of rabi crops. It leads to the increased moisture content in soil profile which reduces moisture stress on plants during the drought period. This method is most suitable for wide-spaced crops viz. cotton, maize, vegetables, etc.

ii. Broad bed and furrow system: This system has been developed by the ICRISAT in India. It is primarily advocated for high rainfall areas (>750 mm) having black cotton soils (Vertisols). Beds of 90–120 cm width are formed, separated by sunken furrows of about 50–60 cm wide and 15 cm depth. The preferred slope along the furrow is between 0.4 and 0.8% on Vertisols. Two to four rows of the crop can be grown on the bed, and the width and crop geometry can be adjusted to suit the cultivation and planting equipment.

Advantages

- Increase in-situ soil moisture conservation
- Safely dispose of excess runoff without causing erosion
- Improved soil aeration for plant growth and development
- Easier for weeding and mechanical harvesting
- It can accommodate a wide range of crop geometry.

Mechanical Measures

Mechanical measures or engineering structures are designed to modify the land slope, to convey runoff water safely to the waterways, to reduce sedimentation and runoff velocity, and to improve water quality. These measures are either used alone or integrated with biological measures to improve the performance and sustainability of the control

measures. In highly eroded and sloppy landscape biological measures should be supplemented by mechanical structures. A number of permanent and temporary mechanical measures are available such as terraces, contour bunding, check dams, gabions, diversion drains, geo-textiles, etc.

The mechanical measures are preferred based on the severity of erosion, soil type, topography, and climate.

Bunding

- ***Contour bunding:*** Contour bunding is used to conserve soil moisture and reduce erosion in the areas having 2–6% slope and mean annual precipitation of <600 mm with permeable soils . The vertical interval between two bunds is known as the spacing of bunds. The spacing of bund is dependent on the erosive velocity of runoff, length of the slope, slope steepness, rainfall intensity, type of crops, and conservation practices.
- ***Graded bunding:*** Graded bunds are made to drain out of excess runoff water safely in areas having 6–10% land slope and receiving rainfall of >750 mm with the soils having infiltration rate < 8 mm/h.
- ***Peripheral bunds:*** Peripheral bunds are constructed around the gully head to check the entry of runoff into the gully. It protects the gully head from being eroded away through erosion processes. It creates a favourable condition for the execution of vegetative measures on gully heads, slopes, and beds.

Contour bunds

Contour Trenching

Trenches are constructed at the contour line to reduce the runoff velocity for soil moisture conservation in the areas having <30% slope. Bunds are formed on the downstream side of trenches for the conservation of rainwater. Trenches are of two types:

- ***Continuous contour trenches:*** Continuous contour trenches are constructed based on the size of the field in the low rainfall areas with the 10–20 cm trench length and 20–25 cm equaliser width without any discontinuity in trench length (10–20 m).
- ***Staggered contour trenches (STCs) Generally***, these trenches are constructed in alternate rows directly beneath one another in a staggered manner in the high rainfall areas, where the risk of overflow is prominent. SCTs are 2–3 m long with 3–5 m spacing between the rows. Planting of tree species is done based on the land slope. It is highly effective in forestalling extension of gully head, soil loss, and arrest the overflow.

Terracing

Terraces are earthen embankments built across the dominant slope partitioning the field in uniform and parallel segments. Generally, these structures are combined with channels to convey runoff into the main outlet at reduced

velocities. It reduces the degree and length of slope and thus reduces runoff velocity, soil erosion and improves water infiltration. It is recommended for the lands having a slope of up to 33% but can be adopted for lands having up to 50–60% slope, based on socio-economic conditions of a particular region. Where plenty of good-quality stones are available, stone bench terracing is recommended. Sometimes, semi-circular type terraces are built at the downstream side of the plants, known as half-moon terraces. Based on the slope of benches, the bench terraces are classified into the following categories:

- Bench terraces sloping outward: These types of terraces are used in low rainfall areas having permeable soils. A shoulder bund is provided for stability of the edge of the terrace and thus has more time for rainwater soaking into the soil.
- Bench terraces sloping inward (hill-type terraces): These types of bench terraces are suitable for heavy rainfall areas where a higher portion of rainfall is to be drained as runoff. For this, a suitable drain should be provided at the inward end of each terrace to drain the runoff. These are also known as hill-type terraces.
- Bench terraces with level top: These types of terraces are suitable for uniformly distributed medium rainfall areas having deep and highly permeable soils. These are also known as irrigated bench terraces because of their use in irrigated areas.

Check Dams

Check dams are effective for preventing runoff rate and severe erosion in steep and broad gullies, and most suitable for high elevation areas of the catchment.

These structures are cheap, have a long life, and fewer maintenance requirements.

The depth of the gully bed is kept about o.3 m and flat stones of 20–30 cm size are used for the construction of dams. A spillway is provided in the middle of the dam to allow the safe discharge of runoff water. Similarly, gabion check dams are also used for drainage line treatment in sharp slanted gullied areas to check sedimentation, erosion, and to conserve soil moisture.

Brushwood Check Dams

Branches of tree and shrub species are staked in two rows parallel to each other filled with brushwood and laid across the gully or way of the flow. These are usually built to regulate the overflow in small and medium gullies which are supplemented with vegetative barriers for long term effectiveness. There is enough soil volume to establish the vegetation. The tree species are planted in 0.3 m × 0.2 m trenches across the way of gullies. It reduces the runoff velocity, soil loss, and improves soil moisture which helps in the successful establishment of vegetative barriers.

Diversion Drains

The channels are constructed to protect the downstream area and for safe draining and diverting of runoff water. It is applicable in high rainfall areas to control runoff losses during the initial stage. The gradient of diversion drain should preferably be kept within 0.5%. Generally, a narrow and deep drain does not get silted up as rapidly as a broad and shallow drain of the same cross-sectional area. Soil dug from the drain should be dumped on the lower side of the drain. Outlet end should be opened at natural drainage lines.

Conservation Bench Terrace

The some of the future concern for soil and water conservation and sustainable agriculture are:

- Formulation of new policies and development of new technologies based on social, economic and cultural aspects of a particular region.
- Implementation and adoption of effective conservation measures for sustaining agricultural productivity.
- Existing soil and water conservation practices should be improved and developed based on the level of natural resources degradation.
- Greater emphasis should be given on participatory approach for effective soil and water conservation.
- Post impact assessment and monitoring of soil and water conservation measures should be done to evaluate their efficacy in increasing productivity, monetary returns, and livelihood of the stakeholders.
- Development of cost-effective conservation practices to restore the degraded lands and to sustain agricultural productivity.

- The efficient technologies for soil and water conservation should be demonstrated on farmers' fields with their active participation.
- Emphasis on research, education and extension of soil and water conservation effective technologies to the stakeholders.
- Adoption of efficient management practices and judicious use of soil and water resources.

2.2.4 SUB-MODULE 4: MANAGEMENT OF PROBLEMATIC SOILS

Introduction

Problematic or problem soils refer to soils that possess characteristics that make them uneconomical for the cultivation of crops without adopting proper reclamation measures. There are three major types of problem soils.

- Physical problem soils
- Chemical problem soils
- Biological problem soils

Soils with Physical Problems for Agricultural Production

Physical problematic soils are those soils whose physical properties have some limitations. They include impermeable soils, soil surface crusting and sealing, subsoil hardpan, shallow soils, highly permeable soils, heavy clay soils and fluffy paddy soils slow permeable soils/ impermeable soils

Slow permeable soils are soils with very high clay content. The clay content restricts infiltration rate and encourages runoff, erosion and nutrient removal from the top layers of soil. Such soils have very poor drainage, aeration and suffer from reducing conditions.

Impermeable soils can be managed adoption of the following practices:

- Addition of organic matter such as farmyard manure (FYM), compost, composted coir pith and press mud improves physical properties leading to improved water retention capacity.
- Ridges and furrows within the farm provide adequate root zone aeration.
- Broad/cumbered beds reduce the amount of water retained in black clay soils during first days of rainfall. The beds should be formed either along the slope or across the slope with drainage furrows in between broad beds.
- Provision of open or subsurface drainage to reduce waterlogged conditions.
- Huge quantity of sand /red soil application to change the texture contour /compartmental bunding to increase the infiltration. Application of soil conditioners like vermiculite to reduce runoff and erosion

Soil Surface Crusting and Sealing

Soil sealing and hard setting or soil capping are common problems in most soils in sub humid and semi-arid tropics. Soil sealing refers to formation of a thin impermeable layer on dry soils due to impact of rain drops while surface crust refers to the formation of a compact layer within a few millimetres to a few centimetres' depth. The crusts are formed by either physical forces such as livestock trampling or traffic by agricultural machinery and other off roading vehicles or chemically by presence of colloidal oxides of iron and aluminium that binds soil particles together in wet soils. Such soils may have the following problems:

- Poor seed germination or retarded root growth
- Poor infiltration rates and high runoff rates
- Poor aeration within the rhizosphere
- Poor biological nitrogen fixation due to poor nodule development in legumes.
- Soils with surface seal or crusting problems can be managed by the following practices:

- Application of organic matter to improve soil physical properties
- Ploughing to break the seal and surface crust.
- Scraping the surface soil by tooth harrow will be useful.
- Bold grained seeds may be used for sowing on the crusted soils.
- More seeds/hill may be adopted for small, seeded crops.
- Sprinkling water at periodical intervals may be done wherever possible.
- Resistant crops like cowpea can be grown.
- Lime or gypsum may be uniformly spread before ploughing in severely crusted soils.

Sub Soil Hard Pan

This refers to a compacted subsurface soil layer. The compact layer is formed by accumulation of clay below the surface causing the subsoil to be dense, difficult for roots and water to penetrate hence leading to reduced water and nutrient uptake and low crop yields. Such soils are also susceptible to soil erosion. Subsoil hard pan can be managed by the following practices:

Deep cultivation

Ploughing with chisel plough, at 50 cm interval in both the directions. Chiseling helps to break the hard pan in the sub soil besides it ploughs up to 45 cm depth.

Application of organic matter

Application of farmyard manure or compost or composted coir pith helps in improving the soil physical properties.

Shallow Soils

Shallow soils refer to soils with less than 50cm depth. Soils having a depth of 50-100cm are referred to as moderately deep soils while soils with a depth greater than 100cm are referred to as deep soils. Most shallow soils are found on high mountains and valleys, and they basically occur in areas where soils are not well formed. Shallow soils have severe limitations to agricultural use. They restrict root elongation, spreading, water and nutrient holding capacity and crop uptake. Shallow soils can be managed through growing shallow rooted crops and frequent soil fertility or water management practices.

Highly permeable soils (sandy soils)

Sandy soils containing more than 70 percent sand fractions are referred to as highly permeable. Such soils have poor nutrient and water retention capacity, very high hydraulic conductivity and infiltration rates. The soils normally lack the finer particles, poor organic matter and living organism population; have poor temperature regulation, weak aggregate stability and very poor soil structure. These soils have poor soil fertility and nutrients and water added are subject to loss through deep infiltration and do not benefit the target crops.

Sandy soils can be managed by adoption of the following practices:

- Application of organic matter such as farmyard manure or compost or slurry to improve soil aggregation.
- Crop rotation with green manure crops.
- Frequent irrigation with low quality water.
- Frequent split application of fertilisers.
- Uniform ploughing.
- Application of clay soil depending on availability of clay materials.

Heavy Clay Soils

Clay soils are those whose particles are less than 0.002mm in diameter. These soils have poor permeability, but their permeability differs with clay content. Most soils are classified as clay soils when they are made up of about 40% clay particles. An example of a heavy clay soil is Vertisol.

Soils with chemical problems include acid soils and salt affected soils.

Acid soils

Soil with pH of less than 7 is generally referred to as acid soils. The acidity level however increases pH decrease from 7 towards zero with pH levels lower than 5.5 being strongly acidic and pH of less than 4.75 being extremely acidic.

Acidity in soils can be caused by mineralogy of parent material, organic matter accumulation, leaching of base cautions (calcium, magnesium, potassium, and sodium), and management practices such as continuous use of acid forming fertilisers, application of elemental sulphur which undergoes reactions forming sulphuric acid, tillage practices and soil pollution.

At pH levels less than 5.5 most micronutrients are abundant and soluble except molybdenum. Some of the abundant micronutrients are toxic to plant roots and soil microorganisms. Oxides and hydroxides of some micronutrients like aluminium (Al) and iron (Fe) form insoluble complexes with important nutrients like phosphorus hence making them unavailable for plant and microorganisms' uptake. At pH less than 5.5, some base cations such as calcium and magnesium are also low, which adversely affects the base saturation levels.

Soil acidity can be managed by application of organic amendments such as manure. Organic matter is a strong buffering agent that buffers the soil against drastic changes in pH on top of replenishing soil nutrients. Application of pulverised limestone or dolomitic limestone (which has magnesium in addition to calcium carbonate that makes up regular lime) is one the fastest ways to increase soil's pH or reduction of soil acidity. It should however be noted that liming materials should be added periodically depending on the nature and level of acidity in particular soils. Basic slag obtained from the iron and steel industry can be substituted for lime because it contains 48-54%CaO and 3-4%MgO. Calcium ammonium phosphate fertilisers, citrate soluble phosphate fertilisers and potassium sulphate are suitable sources of N, P and K respectively in acidic soils.

Saline Soils

Saline soils are non-sodic soils containing sufficient soluble salt to adversely affect the growth of most crop plants with a lower limit of electrical conductivity of the saturated extract (ECe) being 4 Deci Siemens / meter (dS/m), which is equivalent to a value of 4 mmhos/cm. These salts might originate from parent rock from which the soils were formed or from sea water in low lying areas along the coastal strip. A very common source of salts in irrigated soils is the irrigation water. Most irrigation waters contain some salts. After irrigation, the added water is used by the crop or evaporates directly from the soil then salt is left behind. If not removed, the salts accumulate over time in a process called salinization. Salty underground water may also contribute to salinity when the water table rises. For example: irrigation without proper drainage may cause salty groundwater to rise to upper layers thus supplying salts to the root zone. Very salty soils are sometimes recognizable by a white layer or dry salt on the soil surface.

The reclamation of saline soils involves basically the removal of salts from the root zone soil through the processes of leaching with water and drainage. Provision of lateral and main drainage channels of 60 cm deep and 45 cm wide and leaching of salts could reclaim the soils. Sub-surface drainage is an effective tool for lowering the water table, removal of excess salts and prevention of secondary salinization.

Irrigation of Saline Soils

Proportional mixing of good quality (if available) water with saline water and then using it for irrigation reduces the effect of salinity. Alternate furrow irrigation favours growth of plants rather than flooding. Drip, sprinkler, and pitcher irrigation have been found to be more efficient than the conventional flood irrigation method since a relatively lesser amount of water is used under these improved methods.

Fertiliser Management for Saline soils

Addition of extra dose of nitrogen to the tune of 20-25% of recommended level will compensate for the low availability of N in these soils. Addition of organic manures like, FYM, compost, etc. helps in reducing the ill effect of salinity due to release of organic acids produced during decomposition. Green manuring and or green leaf manuring also counteracts the effects of salinity.

Sodic Soils

From an agricultural standpoint, sodic soils are soils containing sufficient exchangeable sodium to adversely affect the growth of most crop plants. These soils have high levels of exchangeable sodium (Na) and low levels of total salts

caused by natural presence of minerals producing sodium carbonate (Na2CO3) or sodium bicarbonate (NaHCO3) upon weathering. They are usually defined as containing an exchangeable sodium percentage greater than 15% and a pH of 8.2 or more. Extreme cases may have a pH of above 10.5. These soils tend to occur within arid to semiarid regions and are innately unstable, exhibiting poor physical and chemical properties, which impede water infiltration, water availability, and ultimately plant growth. Sodic soils may impact plant growth by a) sodium toxicity to sodium sensitive plants; b) Nutrient deficiencies or imbalances; c) High pH of > 8.0 and d) soil structure destruction or dispersion or flocculation of clay minerals.

Sodic soils can be reclaimed or managed using several approaches, they include:

- Establishment of sodic tolerant crops
- Application of organic manures
- Application of chemical amendments such as soluble calcium salts (gypsum, calcium chloride), acids or acid forming substances (sulphuric acid, iron sulphate, aluminium sulphate, lime-sulphur, and pyrite) or calcium salts of low solubility like ground limestone. The compounds in the salts or acids react with the sodium carbonate (Na2CO3 or NaHCO3) forming a leachable compound.
- Agronomic management such as planting at the edge of hills, leaching, crop rotation among others.

Alkaline Soils

Alkaline soils are clay soils with high pH, poor soil structure and low infiltration capacity. Often, they have a hard calcareous layer at 0.5 to 1 metre depth. The causes of alkaline soils are natural or can be man-made. Natural causes are the presence of minerals producing sodium carbonate (Na2CO3) or sodium bicarbonate (NaHCO3) upon weathering.

Alkaline soils with solid CaCO3 can be reclaimed with grass cultures, organic compost, waste hair and feathers, organic garbage, etc. Ensuring the incorporation of much acidifying materials (inorganic or organic material) into the soil and enhancing dissolved Ca in the field water by releasing CO2 gas. Deep ploughing and incorporation of the calcareous subsoil into the topsoil also helps.

Soils with Unfavourable Biological Properties for Agricultural Production

Soils with unfavourable biological properties for agricultural production are soils whose biological properties have some limitations. These include soils with undesirable biological properties like low organic matter content and harmful macro and microorganisms. Bacterial wilt, Fusarium wilt and nematodes are some of the unfavourable biological soil pathogens.

Biological properties of soils-Soil organisms break down organic matter and while doing so make nutrients available for uptake by plants. The nutrients stored in the bodies of soil organisms prevent nutrient loss by leaching. Microbes also maintain soil structure while earthworms are important in bioturbation in the soil. Biological degradation of soil refers to the impairment or elimination of one or more “significant” populations of microorganisms in soil, often with a resulting change in biogeochemical processing within the associated ecosystem

2.2.5 SUB-MODULE 5: IRRIGATION AND DRAINAGE

Introduction

In the dry lands of sub-Saharan Africa, water deficit is the most important environmental factor limiting yields in agriculture. When irrigated, these areas can have a high yield potential because of the high solar radiation, favourable day and night temperature and low atmospheric humidity, conditions that decrease the incidence of pests and diseases compared to areas in temperate zones. The key to maximising crop yields per unit of supplied water in dry lands is ensuring that as much as possible of the available moisture is used through plant transpiration and as little as possible is lost through soil evaporation, deep percolation, and transpiration from weeds.

In recent years there has been growing concern at the performance of conventional irrigation systems in sub-Saharan Africa. The poor performance of irrigation projects seems to have contributed to stagnation in new irrigation development. Available data suggest that irrigation potential in the region is considerable but largely unexploited.

The anticipated long-term yield increases for irrigated land which earlier depended on unpredictable and unreliable rainfall have not always been achieved. This has contributed to irrigation losing its appeal as an investment strategy. Good performance in irrigation systems is not only a matter of high output but also of efficient use of available resources. For example, the inefficient use of irrigation water in arid areas is not only wasteful but often leads to salinization of the soil profile. Irrigation systems that are to be effective and efficient must ensure that drainage, maintenance of soil fertility and salinity-control measures are employed.

Major Methods of Irrigation

Irrigation water is applied to land by three general methods: surface irrigation, sprinkler irrigation and localised irrigation systems. The choice of irrigation method is site specific and depends on topography, the amount of water available, the quality of the water and soils, as well as economic and social considerations.

Surface Irrigation

The surface method of irrigation involves applying water over the soil surface. The water is conveyed over the soil surface and infiltrates into the soil at a rate determined by the infiltration capacity of the soil. Surface irrigation methods include:

Basin irrigation where water is applied to a flat area surrounded by dikes. The water ponded in the basin area continues to percolate into the soil sometime after the stream has been turned off. Basin irrigation stream sizes are usually 15.240 litres per second depending on soil texture, field size, required depth of irrigation and bund height.

Advantages

- Check basins are useful when leaching is required to remove salts from the soil profile.
- Rainfall can be conserved, and soil erosion is reduced by retaining large part of rain
- High water application and distribution efficiency.

Limitations

- The ridges interfere with the movement of implements.
- More area occupied by ridges and field channels.
- The method impedes surface drainage
- Precise land grading and shaping are required
- Labour requirement is higher.
- Not suitable for crops which are sensitive to wet soil conditions around the stem.

Border Irrigation

Border irrigation where water is allowed to flow down a gentle slope (< 0.1%) between bunds. The water advances slowly down the strip and is stopped when sufficient water has infiltrated at the top of the border strip. Border stream sizes are usually 2.15 l/s/m depending on soil type, slope, width and length of border strip and depth of irrigation.

Advantages

- Border ridges can be constructed with simple farm implements like bullock drawn “A” frame ridger or bund former.
- Labour requirement in irrigation is reduced as compared to conventional check basin method.
- Uniform distribution of water and high-water application efficiencies are possible.
- Large irrigation streams can be efficiently used.
- Adequate surface drainage is provided if outlets are available.

Furrow irrigation

Furrow irrigation where water is allowed to flow down slope in small channels (furrows) between crop rows. The

water is gradually absorbed into the bottom and sides of the furrow to wet the soil. Furrow irrigation stream sizes are usually 0.2.3.0 l/s.

Advantages

- Water in furrows contacts only one half to one fifth of the land surface.
- Labour requirement for land preparation and irrigation is reduced.
- Compared to check basins there is less wastage of land in field ditches.

There are 2 types of furrow irrigation based on alignment of furrows

- Straight furrows
- Contour furrows

There are 2 types of furrow irrigation based on size and spacong

- Deep furrows
- Corrugations

Based on Irrigation:

- All furrow irrigation: Water is applied evenly in all the furrows and are called furrow system or uniform furrow system.
- Alternate furrow irrigation: It is not an irrigation layout but a technique for water saving. Water is applied in alternate furrows for e.g. During first irrigation if the even numbers of furrows are irrigated, during next irrigation, the odd number of furrows will be irrigated.
- Skip furrow irrigation: They are normally adopted during the period of water scarcity and to accommodate intercrops. In the skip furrow irrigation, a set of furrows are completely skipped out from irrigation permanently. The skipped furrow will be utilised for raising intercrop. The system ensures water saving of 30-35 per cent. By this method, the available water is economically used without much field reduction.
- Surge irrigation: Surge irrigation is the application of water into the furrows intermittently in a series of relatively short ON and OFF times of irrigation cycle. It has been found that intermittent application of water reduces the infiltration rate over surges thereby the waterfront advances quickly. Hence, reduced net irrigation water requirement. This also results in more uniform soil moisture distribution and storage in the crop root zone compared to continuous flow. The irrigation efficiency is between 85 and 90%.

Surface irrigation, however, may not be appropriate for porous soils (final infiltration rates > 7 cm/h) such as sandy soils, or soils with final infiltration rates that are too low (< 0.3 cm/h). Although surface irrigation can be efficient (70% or more), in a typical farmer's situation less than half of the applied water reaches the plant because of poor irrigation practices. Higher efficiencies can be obtained where land characteristics are suitable for surface irrigation with proper design and better water management.

Sprinkler Irrigation

In overhead sprinkler irrigation, water is distributed in pipes under pressure and sprayed into the air so that the water breaks up into small water droplets that fall to the ground like natural rainfall. Sprinkler irrigation methods include conventional sprinklers, rain guns, centre pivot and linear move systems. Compared to surface irrigation, sprinkling generally requires less land levelling, can be adapted to sandy and fragile soils and requires less labour. However, higher pumping energy is required to lift the water and create enough pressure to operate the sprinklers. Care must be taken to sprinkle the water at rates lower than the soil's final infiltration rate. This is especially important on heavy soils and sloping land where proper management of the soil is essential to ensure that the soil's infiltration rate is not reduced below the rate at which sprinklers apply the water.

A typical application efficiency is 75%, that is, some three-quarters of the applied water reaches the roots of the plant, while one-quarter is lost through deep percolation, runoff, and evaporation losses.

There are 2 types of sprinkler systems

- 1. Rotating head (or) revolving sprinkler system
- 2. Perforated pipe system

Based on the Portability

- ***Portable system***: It has portable mainlines and laterals and a portable pumping unit
- ***Semi portable system:*** A semi portable system is similar to a fully portable system except that the location of the water source and pumping plant are fixed.
- ***Semi-permanent system:*** A semi-permanent system has portable lateral lines, permanent main lines and sub mains and a stationary water source and pumping plant. The mainlines and sub-mains are usually buried, with risers for nozzles located at suitable intervals.
- ***Solid set system:*** A solid set system has enough laterals to eliminate their movement. The laterals are placed in the field early in the crop season and remain for the season.
- ***Permanent system:*** It consists of permanently laid mains, sub-mains and laterals and a stationary water source and pumping plant. Mains, sub-mains and laterals are usually buried below plough depth. Sprinklers are permanently located on each riser.

Advantages

- Water saving to an extent of 35-40% compared to surface irrigation methods.
- Saving in fertilisers - even distribution and avoids wastage.
- Suitable for undulating topography (sloppy lands)
- Reduces erosion
- Suitable for coarse textured soils (sandy soils)
- Frost control - protect crops against frost and high temperature
- Drainage problems eliminated
- Saving in land
- Fertilisers and other chemicals can be applied through irrigation water

Disadvantages

- High initial cost
- Efficiency is affected by wind
- Higher evaporation losses in spraying water
- Not suitable for tall crops like sugarcane
- Not suitable for heavy clay soils
- Poor quality water cannot be used (Sensitivity of crop to saline water and clogging of nozzles).

Localised Irrigation Systems

Localised irrigation systems apply water directly where the plant is growing thus minimising water loss through evaporation from the soil. Such localised irrigation systems include drip irrigation, porous clay pots, porous pipes, and perforated plastic sleeves.

Drip Irrigation

With drip or trickle irrigation the water is applied into the soil through a small-sized opening directly on the soil surface or buried in the soil. By applying water at a very slow rate, drip irrigation can deliver water to the roots of individual plants as often as desired and at a relatively low cost. Because drip irrigation makes it possible to place

water precisely where and when needed with a high degree of uniformity and efficiency (90% or more) the method is useful under many field and water situations.

Losses to runoff, deep percolation and evaporation are minimal; this means that most of the irrigation water is taken up by the plant. Drip irrigation is often the favoured method of irrigation, for example on steep and undulating slopes, for porous soils, for shallow soils, fields having widely varying soils, where water is scarce, where water is expensive, and where water is of poor quality.

Components

- A drip irrigation system consists of a pump or overhead tank, main line, and sub-mains.
- The mainline delivers water to the sub-mains and the sub-mains into the laterals.
- The emitters which are attached to the laterals distribute water for irrigation.
- The mains, sub-mains and laterals are usually made of black PVC (poly vinyl chloride) tubing. The emitters are also made of PVC material
- The other components include regulator, filters, valves, water metre, fertiliser application components, etc.

Advantages

- Water saving - losses due to deep percolation, surface runoff and transmission are avoided. Evaporation losses occurring in sprinkler irrigation do not occur in drip irrigation.
- Uniform water distribution
- Application rates can be adjusted by using different size of drippers
- Suitable for wide spaced row crops, particularly coconut and other horticultural tree crops
- Soil erosion is reduced
- Better weed control
- Land saving
- Less labour cost

Disadvantages

- High initial cost
- Drippers are susceptible to blockage
- Interferes with farm operations and movement of implements and machineries
- Frequent maintenance
- Trees grown may develop shallow confined root zones resulting in poor anchorage.

Drip irrigation demonstration trials at KALRO-Kabete

Porous Clay Pots

This is a method of irrigation in which water is stored in clay pots buried in the ground, from where it is slowly released to the plants. This method is good for fruit trees. Such use of soil-embedded porous jars is one of the oldest continuous irrigation methods that probably originated in the Far East and North Africa. The method consists of:

Clay pots that are placed in shallow pits dug for this purpose.

Soil is then packed around the neck of the pots so that the necks protrude a few centimetres above the ground surface. Water is poured into the pots, either by hand or by means of a flexible hose connected to a water source. The pots are made of locally available clay with optimum properties of strength (to resist crushing), permeability (to exude water into the soil at an approximately steady rate), and size (to hold enough water for at least one day's supply). The potential of clay-pot irrigation has not been fully exploited by farmers in the eastern and southern Africa region, even though the technology is suitable for small- scale farmers. There have not been many reports of previous experience in the region.

Porous Clay Pipes

Water is spread along a continuous horizontal band in the soil. This method is most suited to closely spaced crops such as vegetables. The locally made clay pipes are approximately 24 cm in length and 7.5 cm in internal diameter, with wall thickness of 2 cm. The pipes are placed at the bottom of a shallow trench (about 25 cm deep) representing the centre line of a 1-m wide bed.

Perforated plastic sleeves

Plastic sheeting has been used to make a sleeve-like casing. The advantage of this is the low cost. However, the method has several distinct disadvantages that restrict the range of its applicability. Since the soft plastic material used for making the sleeve does not retain its shape, the sleeve must be filled with sand before being placed in the soil. The sand filling reduces the capacity of the sleeve by some 50.60%. Moreover, the sand itself tends to retain a significant fraction of the moisture and thus to restrict outflow.

Since the plastic casing is essentially impervious, it must be perforated. The difficulty of standardising the diameter and density of the perforations introduces another variable onto the system. The best configuration must be established by trial and error.

This method has been used with success in Senegal. An interesting variation in Sri Lanka consists of a 50-cm long PVC pipe of standard ½-inch diameter. The pipe ends in an emitter, a block made from a 1:10 cement/sand mixture. The design was found to be effective in enhancing the survival and growth rate of young fruit trees.

Different irrigation methods used in Horticultural crops

Different horticultural crops require different amounts of water during their growth cycle since the amount of water required by different crops varies. Some horticultural crops like sweet capsicum, tomatoes, watermelon, and onions can be efficiently irrigated through drip irrigation systems. The drip system will allow for water and fertiliser to be used efficiently at the root zone of the plants for the crop to benefit effectively, additionally in comparison with other irrigation methods like sprinkler irrigation that cannot be used efficiently during windy climate coupled with the fact that fruits/crops can easily be damaged due to excessive water, drip system allows the crop to benefit from low water use, reduced weed pressure, higher quality produce with low diseases and pest pressure.

POSSIBLE IRRIGATION METHODS FOR DIFFERENT CROPS			
Crop type	Possible irrigation methods	Advantages	Disadvantages
Vegetable crops (Edible plant stems like celery asparagus, cole crops like broccoli and cauliflowers, Solanaceae crops, Bulb crops, salad greens and root crops among others	Drip irrigation	Reduces the water use, increase crop yield and quality	Expensive to installation and maintenance, its labour-intensive and may not be economical in lower value crops
All field crops	Sprinkler irrigation	Suitable for all field conditions, Allows for uniform distribution of water	High initial cost, requires high and continuous power supply
Water logging-sensitive staple food and fibre crops such as Maize, soybeans and cotton	Furrow/flood irrigation	The runoff water can be recycled to improve efficiency	Is the least efficient irrigation method due to water loss through runoff, evaporation, and infiltration

2.2.6 SUB-MODULE 6: AGROFORESTRY SYSTEMS

Introduction/ Concept of Agroforestry

Agroforestry is the deliberate growing of woody perennials (trees, shrubs) as agricultural crops alongside other crops and/or livestock in the same land. Existing trees can be protected and managed, or/and new ones planted. It is estimated that trees occur on 46 percent of all agricultural lands and support 30 percent of all rural populations. Trees are used in many traditional and modern farming and rangeland systems.

Agroforestry has three major attributes: productivity, sustainability, and adaptability. Good agroforestry practices should maintain or increase production (productivity), meet the needs of the present generation without compromising those of future ones (sustainability) and be culturally acceptable and environmentally friendly (adoptability).

Components of an Agroforestry System

- Land. This is managed for the benefit of the landowner, environment, and long-term welfare of society, especially in the case of hillside farming where agriculture may lead to rapid loss of soil. Unfortunately, farmers who rent land may have less interest in the long-term benefits of agroforestry.
- Trees. Particular attention is placed on multiple purpose trees or perennial shrubs. The most important of these trees are the legumes because of their ability to fix nitrogen and thus make it available to other plants. The roles of trees may include sources of fruits, nuts, edible leaves, and other food; construction material; non-edible materials including sap, resins, tannins, insecticides, and medicinal compounds; fuel; beautification; shade; soil conservation; improvement of soil fertility.
- Non-trees. Any crop plant can be used in agroforestry systems. The choice of crop plants should be based on those crops already produced in a particular region either for marketing, feeding animals, or for home consumption, or that have great promise for production. Other values to be considered in crop selection include proper nutrition, self-sufficiency, and soil protection; knowledge of the crops; adaptations; production uses, as well as family needs; opportunities for markets. Any farm animal can be used in agroforestry systems. The choice of animal will be based on the value the farmer places on animal-derived benefits including income, food, labour, non-food products, use of crop residues, and manure.

Some of the Agroforestry Tree Species in East Africa

Some of the common agroforestry trees species include Markhamia lutea, Acacia mearnsii, Grevillea Robusta, Moringa oleifera, Calliandra calothyrsus, Gliricidia sepium

Agroforestry and crop production in Kalacha Marsabit County

Common Agroforestry Systems and Land-Use

Agri-Silviculture: It is the growing of agricultural crops as a primary component with the secondary component of multipurpose trees (MPTs) on the same managed land unit. The tree species bind soil particles in the root zone and increase water infiltration and reduce runoff.

Agri-Horticulture: Growing of agricultural crops and fruit trees on the same managed land unit is known as agri-horticulture. Fruit tree species like lemon (Citrus limon), mango (Mangifera indica), ber (Ziziphus Mauritania), and aonla (Phyllanthus emblica) can be successfully planted in agricultural fields and on degraded and low fertile lands with some restoration measures.

Alley Cropping: Growing of agricultural crops in the alley formed between the hedge rows of leguminous nitrogen-fixing tree species. This system is one of the effective measures for soil and water conservation in hilly areas.

Silvi-pasture System: Raising grasses or livestock with MPTs on the same managed land unit is known as the silvi-pasture system. This system has the potential to reclaim eroded and degraded lands. Mechanical measures combined with grass species cultivation are more effective for controlling soil erosion processes.

The grass species such as Cenchrus ciliaris (buffel grass), Cenchrus setigerus (bird wood grass), Dichanthium annulatum (marvel grass), Panicum antidotale (blue panic grass), Panicum maximum (Guinea grass), Brachiaria mutica (para grass) and Pennisetum purpureum (elephant grass) are important in ravine restoration.

Further Reading

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2.3 MODULE 3
CROP PRODUCTION AND MANAGEMENT

Introduction

Crop production plays a significant role in economic development as a source of; Income, employment creation, and saving on foreign exchange earnings through export of produce. Crop production faces numerous challenges including: drought, unreliable and inadequate rainfall,desert locust invasions, among other challenges which make farmers increasingly vulnerable. Proper crop management practices can improve production and improve the overall livelihoods of farmers.

This module focuses on crop production of selected crops that can be grown in marginalised areas under rainfed as well as irrigated agriculture. The module is divided into the following sub-modules;

- Sub-Module 1:Crop value chains suited for ASAL agro-ecological zones
- Sub-Module 2: Cropping systems and technologies
- Sub-Module 3: Integrated pest and disease management
- Sub-Module 4: Harvest and post -harvest handling, management and marketing

2.3.1 SUB-MODULE 1: CROP VALUE CHAINS SUITED FOR ASAL AGRO-ECOLOGICAL ZONES

The need for identification and targeting of crops and crop varieties suitable to different agro-ecological zones cannot be overemphasised for increased agricultural productivity and output. Inadequate information and skills as well as poor market information makes it difficult for farmers to engage in certain crop enterprises. This sub module provides guidance on the relevant skills and information needed to promote crop value chains for the targeted agro ecological zones.

Sorghum (*Sorghum bicolor*)

Sorghum crop (Photo: Sorghum extension Manual, KALRO.org)

Sorghum is a member of the grass family, grown majorly for the seed/grain as human food and foliage for livestock. It is a drought tolerant crop and is an important food and nutritional security crop especially in semi-arid lands (SALs). The grain is high in energy and nutritional levels, suitable for consumption by all. Grains can be boiled, ground for Ugali and porridge, malted for beer, baked, popped for snacks, among others. Sorghum has the ability to ratoon after

harvest which minimises the costs of land preparation and planting. Production varies from 8 to 26 bags of 90 kg per acre, depending on the variety and other extrinsic factors.

Ecological Requirements

Sorghum is relatively drought resistant and therefore does well even in drier areas. This is done through the survival tactic and adaptation mechanism where the plant rolls up its leaves to reduce the transpiration rate. Soil– the crop requires a fairly fertile soil which is well drained, clay-loamy soils and a PH of 5.0-8.5.

- Rainfall- an annual rainfall of 250-900 mm is adequate for optimal production of sorghum. The crop is resistant to waterlogging.
- Altitude– the crop grows well in the range of 500 - 5500 m ASL
- Temperature– warm temperatures of between 15-35 ^{o}C is ideal for the sorghum's growth and development.

Selected Varieties

The varieties (Table 2.2) are characterised majorly by seed colour, taste, maturity, adaptation and yield potential. The choice of appropriate sorghum varieties therefore, is very important since specific attributes based on climatic conditions, yield potential, resistance to pests and diseases, maturity period, household utilisation and market preference are considered.

TABLE 2.2. SORGHUM VARIETIES AND SPECIAL ATTRIBUTES

Gadam	Grey, High malting quality	85 – 95 days	1000 -1800
Seredo	Brown, Bird tolerant	110 – 120 days	1000 - 4000
Serena	Brown, Bird tolerant	110 – 120 days	800 - 2500
Mtama 1	White, High malting quality	95 – 100 days	2500 - 4000
Mtama 2	White, High malting quality	95 – 100 days	1000 - 4000
E 1291	Brown, good for sorghum beverage	150 -210 days	2000- 4000
E 6518	Brown, Dual purpose, high quality fodder	210 – 240 days	1500- 3800
IS76	White/Brown, Medium yielding	90-110 days	1800 - 2800
BJ28	Brown, Dual purpose suitable for grain and forage	150-210 days	1000- 3800

Agronomic Practices

Land Preparation and Planting. Sorghum is propagated by seeds. Land should be prepared well in advance during the dry condition and planting done at the onset of rains. The recommendation is to plough the land immediately after harvesting the previous crop. Ploughing should also be done to a fine tilth. Planting is done either by Seeds broadcasted or sown directly into furrows on the well-prepared seedbed. Plant at a depth of 2.5-4.0 cm when the soil is moist and 5 cm when dry. The spacing differ in that, when planting sorghum as a sole crop, the spacing should be 90 cm by 15 cm or 75 cm by 20 cm, when intercropping with legumes, the spacing should be 90 cm by 20 cm for single alternate rows and 120 cm by 20 cm for double rows of legumes. Late planting can lead to reduced yields. Germination will occur within 5-7 days after sowing.

Weeding. It is an essential operation that eliminates competition from other non-desired plants. Weeding should therefore be done within 2-3 weeks after emergence. The second weeding depends on the rainfall and weed density.

Thinning and Roguing. Thinning is done three weeks after emergence and the first thinning when the soil has sufficient moisture to minimise roots disturbance and shock. Leave 2 – 3 plants per hole. Diseased plants should be removed to avoid further spread. This process is called roguing.

Crop Rotation. Crop rotation is highly recommended to reduce build-up of sorghum diseases and insect pests. Avoid rotating sorghum with the members from the same family like maize and millet.

Soil Nutrition Management. To achieve maximum production, the crop should be supplied with enough nutrients. The amount of fertiliser to be applied to the crop however depends on the fertility of the soil. Application of both basal and foliar fertilisers is recommended. At planting apply 1 bag (50 kg) per acre of compound fertiliser NPK (20:20:0, 23:23:0 or 17: 17:17). Top dress with one bag (50 kg) of calcium ammonium nitrate (CAN) per acre preferably after first weeding. Application is done by drilling the fertiliser along the planting furrows and thoroughly mixed with the soil before planting and covering the seed. Manure improves soil organic matter which impacts positively on soil moisture retention and structure. Broadcast well-decomposed manure in the field close to the onset of the rains at a rate of 2 tons per acre and mix it with the soil during ploughing. Manure can also be spread in bands along the planting furrows and mixed with the soil before seeds are sown.

Pests and Disease Management. Integrated pest and disease management is recommended. Important pests and disease for sorghum and their management are summarised in the Tables 2.3 and 2.4.

TABLE 2.3- SORGHUM PESTS AND CONTROL OPTIONS

Shoot fly Source: Karlo sorghum manual 	The yellowish or white maggots bores into the hearts of the shoot causing drying of the central growing shoot (dead heart)	Early uniform planting Spray with systemic insecticide like Atari, Seed dress with systemic insecticide such as Bell amid 600 FS at 3g/1Kg seed
Stalk borers	Caterpillar feed inside the stalks causing a stunted plant growth, windowing of leaves, withered shoots and often and poorly developed heads	Plant early into the season Field sanitation Source:KALRO sorghum manual Apply insecticide into the funnels such as Bullock, Dipteral, Thiodan Practice Push Pull technology by intercropping with desmodium and napier round the edge of the farm
Birds 	Birds are one of the most important pests of sorghum. They are capable of causing heavy losses. The most notorious species is Quelea	Use bird scaring device Destroy their roosting sites Avoid isolated fields Timely harvesting

TABLE 2.4. IMPORTANT DISEASES AND THEIR CONTROL OPTIONS

Anthracnose 	Anthracnose damages foliage and stems of grain sorghum. Dry lesions appear on the leaf surface. A brown sunken area with distinct margins develops appears on the stem holding the head (peduncle). When infected stems are cut lengthwise they have brick-red discolorations. The infection inhibits the flow of water and nutrients to the grain causing poor development.	Plant resistant/tolerant varieties Rotate with non-cereals Preferably with pulses. • Good management of crop residues.
Leaf blight 	Small reddish-purple or yellowish-brown spots on the leaves. Severely affected plants look as if they have been burnt. Under warm, humid conditions the disease may cause serious damage by killing all leaves before plants have matured.	• Plant resistant varieties • Use certified disease-free seeds. • Good management of crop residues.

TABLE 2.4. IMPORTANT DISEASES AND THEIR CONTROL OPTIONS

Leaf rust 	Small raised pustules or blisters on both the upper and lower leaf surfaces that rupture and release many reddish-brown spores. Appears when plants are nearly flowering. Forage yields are affected most. Grain yield losses are usually not serious.	• Use resistant varieties such as KARI Mtama 1 • Rotate with non-cereals. • Control weeds
Long smut 	The spores are seed borne and germinate soon after the seed is planted and invades the young sorghum plant. It continues to grow unobserved until heading stage, when the long pointed smut galls appear in the heads in place of normal grains. Unlike covered smut, this disease stunts the infected plants and often induces abundant side branches.	• Certified disease-free seeds. • Control weeds. • Rotation with non-cereals. • Field sanitation.
Smut 	Black masses of powdery spores instead of grains; the entire head becomes black. Plants become infected while in the seedling stage but infection is not apparent until the heading stage. The smut gall produces thousands of spores, which become soil-borne and initiate systemic infection of seedlings in subsequent years.	Plant resistant hybrids to avoid losses. Use certified disease-free seed. Rotate with non-cereals. Plough deep.
Ergot 	Dark brown to black sclerotia develop in place of seeds on the panicle. The spores are carried by insects or splashed by rain to infect flowers, where they invade the young kernels and replace them with fungal growth. The spores are also seed borne and soil borne but the damage becomes apparent when they reach the flowering stage.	Plant resistant varieties, Remove affected panicles. Plant clean seeds. Plough deep. Rotate with non-cereals Good field sanitation

Maturity, Harvesting and Storage

Sorghum is ready for harvesting 3-4months after sowing, depending on the variety and ecological factors. This is when the grains are about 28 -35 moisture content and do not produce milk when crushed. The heads are cut off with a knife or sickle and sun dried. Alternatively, the entire plant can be cut and the heads removed later. For large scale farming, combine harvesters are used. If the crop is meant for seed production, harvesting should be done at maturity stage while that meant for fodder should be cut when still green and fresh. Seeds are obtained through threshing the dry heads, winnowing and may be seed-dressed for a longer shelf life. They are stored in treated gunny or PICS on pallets, not directly on the floor.

Pearl millet (*Pennisetum glaucum L.*)

Pearl millet head (Photo: KALRO Millet extension manual)

Pearl millet is an annual grass in the family Poaceae. Millets are a group of cereals grown in semi-arid regions, capable of withstanding high temperatures and can also escape drought. The grain can be used for food or for brewing and the straws as animal feed.

Ecological Requirements

Pearl millet is very adaptable to a wide range of environmental and climatic conditions. It thrives at higher elevations compared to other tropical cereals and tolerates salinity better than most cereals. It grows best in an environment with medium rainfall, about 200-900mm, an annual temperature range of 15- 30 °C and in fertile, well-draining sandy loam soil with a pH between 5 - 8.5. The crop performs well in an altitude range of 500 – 2400 m asl. Areas with low rainfall and low relative humidity during seed ripening and maturation are best for regeneration.

Varieties

- **KAT/PM-1**- This is a grey seeded variety that matures between 2-3 months and yields between 8-10 (90KG) bags per acre
- **KAT/PM-2**- A grey seeded variety that matures in 2 months and yield about 7 (90KG) bags per acre
- **KAT/PM-3**- A grey seeded variety that matures between 2-3 months and yields 8-12 (90KG) bags per Acre

Agronomic Practices

Land Preparation. Pearl millet is a small seeded crop and therefore requires a fine seedbed for good seed germination and seedling establishment. A tractor or oxen plough can be used to open the field, harrow to break the large soil boulders. When hand- hoes are used for land preparation, the large soil boulders should be reduced by breaking them to provide a moderately smooth seed bed. Select fields not far from homesteads and avoid bird breeding sites.

Planting. Sowing is usually done by broadcasting or planting the seeds in furrows. The seedbed should be thoroughly prepared to a fine tilth because the seeds are very tiny. Seeds are sown to a depth of 2.5 cm allowing 25 cm between rows and 10–12 cm between plants. Finger millet should be planted as early as possible in the season on the onset of rains. The earlier it is sown the higher the yields. The crop can be planted as a pure stand or intercropped with other crops like beans, and cowpeas, among others. Germination occurs within a week after sowing.

Soil Fertility Management. During planting, it is recommended to apply NPK (20:20:0 or 23:23:0) at a rate of one bag (50 kgs) per acre. In soils with low fertility and in instances where rainfall continues beyond 30 days after planting, top dress with CAN at a rate of one bag (50 kgs) per acre. Apply fertiliser along the furrows and thoroughly mix with soil before placing the seeds.

One can also apply manure to improve nutrients, structure and increase moisture retention capacity level in the soil. Only use well-decomposed manure by broadcasting in the field close to the onset of the rains and mix with the soil during ploughing. In case of low volumes of manure, it can be spread in bands along the planting furrows and mixed with the soil before seeds are placed. Application of farmyard manure at 5 tons acre is recommended.

Weeding and Thinning

- The first weeding should be done within 2-3 weeks after emergence and the second weeding is recommended depending on the weed density. Chemical weeding can also be done using pre-emergence herbicides.
- Thinning should be done when the soil is moist to ensure minimal disturbance of the roots of the remaining plants for a healthy growth. Thinning should be done 3 weeks after emergence (at 3 - 4 th leaf stage and leave 1 plant per hole. This is best done after first weeding in order to accommodate appropriate plant density adjustments, and leaving two plants adjacent to it compensates for a gap within the row.
- Uproot plants that display abnormal characteristics like being taller than other plants, if the flower colour deviates from the majority of other plants, or grain colour that is different from that of the majority of plants.

Pests

Cutworms: These are black or brown in colour and cut off young plants at or slightly below the soil level. The attacked plants may eventually die.

Chafer grubs: These are whitish C-shaped caterpillars found in the soil which feed on the roots and may kill young seedlings.

Stem borer: The larvae/maggots feed on the funnels of the crop before tunnelling down to feed on the developing tissues. Others bore holes straight into the centre of the stem. Feeding causes stunted growth and production of sterile or poorly developed ear heads. In severe cases, the plant dies. Young plants are more susceptible to attack by stem borers

Shoot fly: The larva enters the funnel of the crop and moves down to feed on the young shoot, killing the growing point and the youngest leaf which turns brownish and withers. This damage is commonly referred to as 'dead heart'. Tillers can also be attacked.

Midge: The larvae feed on the developing grains causing them to shrink and flatten. Damaged panicles have small, transparent midge pupa attached to the tips of the damaged spikelets.

Armyworms: These are seriously destructive pests which cause serious damages to mostly the young plants by eating away the leaves. Heavy infestations can cause defoliation.

Aphids: They suck plant sap on the ear heads or on the undersides of the leaves and produce honeydew which encourages development of sooty mould. Infested plants become stunted, leaves dry up and yield is considerably reduced.

Earhead bugs: The adults and nymphs feed on the developing kernels by sucking the juice from within the grains when they are in the milky stage. Kernels shrivel, become small and discoloured, especially if attacked in early development stages.

Diseases

Damping off: Infection causes rotting of seeds before they emerge as well as seedlings after emergence from the soil.

Cercospora leaf spot: Small dark lesions develop on leaves which are usually oval in shape but may be oblong to rectangular. The centres of the lesions are grey to tan in colour with visible black dots and may be covered in spores during wet weather. These lesions may also be present on the stems and are slightly longer than those on the leaves.

Blast: Elliptical or diamond shaped lesions form on leaves. The centres of these lesions are grey and water-soaked, surrounded by chlorotic halo and there is an appearance of concentric rings on leaves

Rust: Small yellow or white raised spots develop on the upper and lower leaf surfaces. These spots tend to be more numerous on lower leaf surfaces. They enlarge and develop into red-brown pustules which may be surrounded by a yellow halo.

Downy mildew: The infected plants develop thick, stiff, twisted, pale green leaves with bumpy surfaces. In severe cases of infection, the plants do not produce.

Maturity, Harvest and Postharvest Handling

Pearl millet is usually ready to harvest between 2.5 and 5 months after sowing depending on the variety.The crop is usually harvested manually by cutting the heads with knives at physiological maturity and sun-dried before threshing and drying to 12 – 13% MC. For large scale farming, combine harvesters are used to cut off the head or the whole plant.

Threshing and sorting of the dry grain can be dusted with Actellic or Actellic for protection against storage pests. If the grain is meant for seed, then it should be dressed with Bellamid 600 FS or Gaucho FS 350 for protection against soil pests.

The grain should be kept in either metal or plastic containers. When sisal bags are used, they should be kept in a cool, dry and well-ventilated place. If grain is kept for more than 90 days especially in hot areas, a second dusting is recommended after 3 months.

Further Reading

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Pigeon peas (*Cajanus cajan*)

Pigeonpea crop (Photo: KALRO Pigeon pea extension manual)

Pigeon pea is a legume crop that belongs to the family Fabaceae. It is commonly cultivated in the semi-arid tropics. In Kenya, pigeon pea is the third most widely grown pulse crop. Besides other regions, pigeon pea is largely cultivated in the Eastern and Coastal regions of Kenya in large pieces of land. Both the green and the dry pulses are consumed locally or exported to other countries like Tanzania, Malawi etc. Pigeon peas can be eaten as vegetables (immature pods or the green pigeon pea) or as dried grains. The crop can be intercropped with other crops like maize, sorghum, cowpeas, beans, cassava, etc.

Varieties

Pigeon pea varieties vary in form of seed, taste, colour, growth habits, flowering time, susceptibility to pathogens, among other traits. The following are some of the most commonly cultivated pigeon pea varieties;

- Mbaazi -1, 2 &3
- Kat 60/8, 81/3/3 & 777
- ICPL 89091
- Local Races

Ecological Requirements

- Temperature: Pigeon pea does well in a temperature range of between 18-38 ^{o}C. The plant cannot withstand frost.
- Rainfall: An annual rainfall range of 600-1000 mm is adequate for the cultivation of this crop. It however flowers well where the rainfall is between 1500-2000 mm. excessive rainfall during flowering causes flower abortion and increased disease incidences. Dry weather conditions are needed during harvesting.
- Soil: The crop thrives in a well-drained soil with an optimal PH of 5-7. It is very sensitive to high salinity and does not tolerate shallow and water logged soils.

Agronomic Practices

Planting. Pigeon pea is propagated by seed. Seeds should be certified and disease free. Damaged or shrivelled seeds should not be planted. Before planting, land should be prepared to a fine tilth. Seeds are directly planted in

a deep ploughed garden, at a spacing of 35-50 cm * 75-150cm, and a depth of about 10cm. However, this spacing depends on the various varieties, soil type, production system of the variety, etc., For instance, in drier regions, a wider spacing is adopted in order to reduce competition for nutrients and water. Planting should be done at the onset of the rains if production is rain fed. Delayed sowing may cause crop failure or reduced yield. Germination takes place within 5-7 days and this depends on the variety and environmental factors. Pigeon peas can be grown as a pure stand or intercropped. When intercropped, spacing is more than when monocropped.

Soil Fertility Management. It is always important to ensure that plants are supplied with sufficient amounts of nutrients. This enables them to carry out their normal activities successfully leading to considerably increased yields. Plants that have been deprived of nutrients are highly susceptible to attack by pathogens, and this affects overall yield directly.

During planting, a mixture of manure and DAP is recommended. In order to enhance efficient nutrient uptake by the young plants as well as stimulating their growth, mix 1 kg HUMIPOWER with 1 ton manure or 50 kg basal fertiliser. 4-5 weeks after germination, it is advisable that top dressing is done. Normally CAN is used, which should also be mixed with HUMIPOWER. However, these basal fertilisers need to be supplemented with foliar fertilisers because they have a wide range of nutrient elements which are very vital to the plants.

Weed Control. Weeds compete with the crop for nutrients, water, space and light. They should thus be controlled in order to facilitate proper growth and development of the crop. During land preparation, spray weeds with CLAMPDOWN 480SL 200 ml/20l. This helps get rid of all types of weeds, leaving the garden weed free.

Pests

Aphids: These are soft bodied insects, usually green, black or brown which suck plant sap. Infested leaves curl and crinkle. They also attack the pods. As they feed, they excrete honeydew which facilitates the development of sooty mould which reduces photosynthetic area. Stunted growth is noted.

Pod sucking bugs: These suck the developing seeds through the wall of the pod causing the seeds to become shrivelled with dark patches. The damaged seeds are not recommended for food and cannot germinate as well. These bugs include; spiny brown bug, giant coreid bug, green stink bug etc.

Red spider mites*:* These feed by piercing and sucking the plant sap. They feed on the underside of the leaf leading to formation of whitish or yellowish patches. Heavy infestations can cause defoliation. These pests form webs on the lower sides of the leaves.

Cutworms: They cut the stem of younger plants below the soil surface. The infested plants wither eventually.

Scales: These appear as small shells glued to the plant and suck sap on any above ground part of the plant. Infested leaves turn yellow and may drop and diebacks of infested branches result. As they feed, they secrete honeydew which facilitates development of sooty mould.

Pod borer: The most common one is the African bollworm. These pod borers feed on leaves, flowers and pods thus damaging them. They bore holes on pods and feed on the seeds.

Pod Fly: This is a small black fly that lays eggs on the pods which hatch into white maggots. These maggots feed on the green seed and later form into brown barrel shaped pupae. The damaged seeds are of no value. They also feed on leaflets and flowers making small holes in them.

Pod Weevil*:* The adult is a small black beetle. The larvae are creamish white and they feed on the green seeds. However, damage is only noticed as the adult comes out of the pod.

Whiteflies*:* Are white insects which suck plant sap. Infested leaves curl, become distorted and eventually drop. They also secrete honeydew as they feed which enhances the development of sooty mould on the leaves affecting photosynthesis.

Thrips: These feed on leaves and flowers by sucking the sap. Heavy infestations cause flower and flower buds abortion. Leaves also may fall off.

Leaf miners: The larva mines under the leaf surface, resulting in formation of mines / winding trails which increase in width as the larvae mature. This reduces photosynthetic area leading to leaf withering.

Root knot nematode: The major characteristic symptom is the development of swellings/galls in the roots which rot as infestation progresses. The infested plant is usually stunted and eventually wilts and dies.

NB: Whenever applying basal fertilisers, mix 50 kg fertiliser e.g. DAP, NPK etc. with 2 kg ADVENTURE. This helps to control nematodes.

Diseases

Cercospora Leaf Spot: infection leads to development of small light brown lesions on the upper surfaces of the leaves. In severe cases of infection, leaves die.

Fusarium Wilt: Attacked plants show sudden yellowing of leaves which eventually fall off, making the plant to wither. There's usually some blackened tissue at the base of the stem. These symptoms can also be found on one side of the plant.

Powdery Mildew: Plant parts are covered with whitish fungal growth. Heavy infestations cause defoliation.

Rust: Lower leaf surface develops dark brown raised pustules which have the fungal growth. As infection progresses, leaves desiccate and fall off. Defoliation occurs in severe cases.

Harvesting and Storage

Depending on the variety, pigeon peas can be harvested 4 - 8 months after planting. They may be harvested while green or when dry and mature pods are picked individually. When most of the pods are mature, the plant can be cut at its base, near the ground. However, this method is rarely practised.

Dry pigeon pea seeds are stored in treated gunny or PICS bags which help to prevent major damages caused by storage pests like brucchids. It is advisable to incorporate the seeds with an insecticide, e.g. Actellic super to prevent pest damage during storage.

Bags should be placed on pallets, not directly on the floor. These can stay up to about 8 months while still in good condition. Once harvested, the green pigeon peas are peeled and cooked. They can also be refrigerated for about 7-10 days. Pigeon peas are rich in vitamins and other nutritional elements. They can be cooked alone to be served with a wide range of foods e.g. rice, or mixed with different grains like maize.

Green gram/mung bean (*Vigna radiata*)

Green gram crop (Photo: KALRO green gram extension manual)

Green gram/Mung bean (*Vigna radiata*) also known as Mung beans and in Kiswahili Ndengu, belonging to the Fabaceae family is an annual leguminous crop which is grown for its seeds, with high nutritional content. They are well suited to diverse environments and fit in various cropping systems, low input requirements, fast growth, nitrogen fixing and weed smothering ability. They are commonly grown in central, south Nyanza, eastern and coastal regions. Its edible grain is characterised by good digestibility, flavour, high and easily digestible protein content and absence of any flatulence effects. It's also a crucial source of vitamins A and B, micronutrients such as iron and zinc which are essential for pregnant women and children.

The crop is easy to cultivate and can grow up to a height of 30-120 cm, producing pods. Dried seeds are cooked or milled into flour, while the crop residues are used as fodder or in making green manure.

Ecological Requirements

Green grams thrive in a well-drained soil preferably sandy loamy soil, rich in nutrients and with an optimum PH of 6.0-7.5. It grows best at an altitude of 0-1600 m with an optimum temperature of between 25-30 ^{o}C. It is relatively drought tolerant and can give reasonable yields with an annual rainfall of between 350 -700 mm. Too much rain or long dry spells reduce yields. Excessive rainfall during flowering causes flower abortion while dry weather conditions are important during harvesting.

Varieties

There are two major varieties that can be differentiated through the grain colour. These are the yellow and the green grain grams. The N26 green gram variety is small and ripens unevenly while the improved variety KS20 has bigger seeds and tends to ripen uniformly

KS20 (uncle) – matures in 80-90 days, pods turn brown when dry while grains are dull green in colour and bigger in size compared to N26

N26 (nylon) – matures in 60-65 days, pods are black when dry and grains are shiny green in colour.

Agronomic Practices

Land Preparation. To realise high yields, select highly productive land suitable. Always avoid steeply sloping land, land which is near a swamp, very sandy soil and areas with shallow surface soil and a lot of couch grass. Land preparation should be done early enough so that the field is free of weeds and ready for planting at the onset of rains. Seed bed should have fine soils. A level seedbed facilitates planting to a uniform depth and uniform distribution of water

Soil Fertility Management. It is advisable to use fertilisers on the basis of soil test and recommendations, a basal dose of NPK (23:23:0) 1 bag (50 kgs)/ acre may be broadcasted. Nitrogen fertiliser is usually not applied as green grams fix their own nitrogen, but 10-20 tons (100-wheel barrows) per acre farm yard manure can be applied. The manure should be broadcasted just before rains start and ploughed in. Fertiliser should be well mixed with the soil before placing the seed. Lime should be applied one year prior to growing green grams and thoroughly incorporated

Planting. Land should be prepared to a fine tilth before planting. Propagation is by seeds. The seeds should be certified or disease free. Damaged or shrivelled seeds should not be planted because they will not germinate or establish well. Seeds are planted at a spacing of 45*15cm, a depth of about 3-5cm. An acre needs 4-6 kg of green gram seeds. Planting should be done at the onset of the rains if production is rain fed. Delayed sowing may cause crop failure or reduced yield. Germination occurs within 5 to 7 days and this depends on the variety and environmental factors. Green grams can be planted alone or intercropped with other crops like maize, sorghum, cowpeas, etc.

Weeding. Weed control in green grams is essential, to reduce competition for nutrients which result in low yields. Weed-free crop of green grams decreases insect pest infestation. The most common weeding method is hand weeding but oxen can be used too. The first weeding should be done 2 weeks after emergence and the second before flowering.

Crop Rotation. Green grams in a mono cropping system should be rotated with non-leguminous crops such as maize, millet, sorghum, sweet potatoes and cassava. This practice is recommended to avoid pest and disease build up. It is not advisable to grow mung beans for two consecutive seasons on the same field. Mung beans leave a nitrogen- rich soil allowing subsequent crops to benefit and grow successfully.

Losses of up to 10-45% in green grams have been associated with common blight while 80% due to angular leaf spot disease. Therefore, pests and disease management is very important for high grain yield and quality.

Pests

Cutworms: These are brown or black caterpillars usually found in the soil, which cut the stem of younger plants below the soil surface. Heavy infestations can lead to total crop loss.

Aphids*:* These are soft bodied, green or black insect pests which suck plant sap. Infested leaves curl and crinkle and attack the pods as well. Aphids excrete honeydew as they feed, which encourages the development of sooty mould..

Pods Sucking Bugs: These include giant coreid bug, green stink bug, etc. they suck sap from the pods and seeds. This may cause necrosis, pod malformation, premature drying, formation of empty pods, shrivelling of seeds, among others.

Pod Borers*:* These include the African bollworm and they feed on leaves, flowers and pods. They bore holes on pods and feed on the seeds, with the heads inside the pods. These borers cause significant losses if not controlled.

Whiteflies: These are white flying insect pests which suck plant sap and secrete honeydew as they feed which facilitates the development of sooty mould. Infested leaves curl, become distorted and eventually drop. They are also vectors of plant diseases.

Foliage Beetles*:* These feed on the leaves leading to defoliation, especially of the young plants.

Thrips*:* These prefer mostly the flowers, although they also feed on leaves and petioles. Attacked flowers turn brown, dry and become distorted. This decreases pollination ability and seed set.

Bean Flies*:* The larvae (small whitish maggots) tunnel through the main stem and feed, causing significant damages. In severe cases of infestations, Seedling may die, leaves of the older plants turn yellow and become stunted while stems get thicker than normal and crooked.

Diseases

Damping off: infection causes rotting of seeds before they emerge as well as seedlings after emergence from the soil.

Anthracnose*:* this attacks all the above ground parts of the crop but pods are mostly damaged, whereby they develop brown sunken lesions. These lesions are covered with pink spores under humid conditions. The seeds become brownish black.

Powdery Mildew*:* Infection causes development of white powdery patches on the leaves and other plant parts which gradually enlarge, covering the entire surface, as infection progresses. Severely infected parts turn yellow and are distorted, defoliation occurs.

Bacterial Blight*:* Infection causes formation of small brown blotches on the leaves which enlarge as infection continues, eventually causing the leaves to fall off and subsequent death of the plant.

Rust*:* On infection, the disease appears as reddish-brown blisters which are found mainly on the underside of the leaves, on pods and stems. In severe cases, both sides of the leaves are covered with rust pustules and defoliation may follow, while pods shrivel.

Yellow Mosaic: This is a viral disease which causes serious losses. It is transmitted by whiteflies. Infected leaves become necrotic, diseased plants are stunted, mature late and produce few flowers and pods. The pods are usually reduced in size and turn yellow.

Control vectors (whiteflies) by spraying TAURUS 500SP 10 g/20l or PROFILE 440EC 30 ml/20l

Green grams mature within 60-90 days after sowing, depending on environmental factors as well as the variety.

Harvesting and Storage

Harvesting should be done when most of the pods have turned black. This is achieved through picking the individual pods or uprooting the entire plant. Delayed harvesting results into shattering of the pods and other losses can occur, e.g. infestation by pests.

The harvested pods should be dried for about 2 to 3 days then threshed and winnowed, ready for consumption or storage.

Green grams are very susceptible to attack by brucchids and should therefore be stored soon after sun drying in airtight containers or gunny bags in a clean ventilated room. Seed treatment is recommended for a longer storage period.Note that proper drying of the green grams is highly required in order to prevent contamination with aflatoxins and development of pathogens. AdditionallyInfected seeds should not be mixed with the sound ones.

Further Reading

Esilaba, A.O. *et al*. (2021). KCEP-CRAL Green Gram Extension Manual. Kenya Agricultural and Livestock Research Organization, Nairobi, Kenya

Cowpeas (*Vigna unguiculata*)

Cowpea seeds and crop (Photo: KALRO cowpea extension manual)

Cowpeas belong to the family *Papilionaceae.* The crop is of major importance to the livelihoods of relatively poor people in developing countries. In Africa It is an important agricultural crop because it is source of nutritious food, high quality of animals feed, importance in cropping system, replenishing degraded soils, suppression of weeds, drought tolerant and source of income

Ecological Requirement

Cowpea is adapted to high temperatures ranging between 20-35 ^{O}C. It does not withstand floods. The crop is fairly tolerant to drought. It requires a rainfall range of 600-1100 mm per annum. Excessive rains lead to delayed ripening and reduced grain yield (Table 2.5). It grows well in a wide range of soil from heavy clay to varying proportions of sand and clay. Cowpeas thrive best in the PH range of 5.5 to 8.5. The crop can tolerate salinity to some extent but can withstand soils with high aluminium.

Varieties

TABLE 2.5. COWPEA VARIETIES WITH DIFFERENT TRAITS

Variety	Maturity in days	Yield potential in 90 kg bag/acre	Traits
Machakos 66 (M66)	80-95	3.5-7.5	Dual purpose erect variety, smooth creamy brown seeds with small eye and tolerant to yellow mosaic virus &scab

TABLE 2.5. COWPEA VARIETIES WITH DIFFERENT TRAITS

Kunde- Tumaini	70-80	6.6-9.4	Deep brown large sized grain, early maturing, semi erect and dual-purpose variety
Kunde- Tamu	70-80	2.5-8.8	Tender and sweet leaves when cooked, brown greenish ring around the helium, semi-erect and dual-purpose variety
KAT- Kunde	80-90	6.2-8.8	Creamy brown grain, semi-erect and dual-purpose variety
Katumani 80 (K80)	75-85	3.5-8	Dual purpose, semi spreading habit, smooth and creamy brown with a small eye grain, resistant to aphids, tolerant to pests and resistant to foliar fungal disease and mosaic virus
Kunde- Soko	80-90	6.2-8.4	Brown Large to medium sized grain, Eye pattern is brown greenish and Semi- erect Variety
KVU-419	65-72	4.4-6.6	Grown for grain rather than leaves. smaller grains than both M66 and K80. Tolerance to cold and recovers very fast from drought
KVU 27-1	70-90	3.5-8	Dual purpose,semi spreading habit, Grains are dark red in colour. Moderately tolerant to pests and resistant to foliar fungal disease and mosaic virus
KVU HB 48E10	85-95	4.8-6.6	More vegetable type than grain type
Kunde 1	75-90	5.3-11	Dual purpose
KCP 022	60-75	11	Drought tolerant
MTW 63	60	11	Pest tolerant
MTW 610	60	9	Large grains
ICV	75	7	Pest tolerant

Agronomic Practices

Land Preparation. Land should be prepared early enough so that the field is free of weeds and ready for planting at the onset of rains. The land should be prepared to a fine tilth and levelled so as to enhance moisture absorption & retention, easy germination & root penetration, ensures better surface contact between the seed and the soil and for uniform depth.

Planting. Cowpeas is planted by direct seeding at a spacing of 60cm × 20cm and 50 cm x 75 cm, depending on the variety. Seeds should be planted at the onset of rains. For a good plant stand and high yields, seeds must be of high quality. For early maturing varieties, planting at the beginning of the rains is advised so that the sensitive stages of the crop avoid the peak activity of insect pests. Ideally, planting should be timely in relation to the maturity period of the variety, such that the crop is harvested during the dry weather.

Fertiliser Requirement. The cowpea is a legume that fixes its own nitrogen. Too much fertiliser will result in heavy vegetative growth and reduce grain production. Use of at least 2 tons/acre of well- decomposed compost or farmyard manure is recommended especially in areas where soils are low in organic matter content. This is best applied under dry conditions and then mixed with the topsoil, about one week prior to planting

Cowpea requires more phosphorus (P) than nitrogen. About 60 kg/acre of (P_2O_5) is recommended for cowpea production to help the crop to nodulate well and fix its own nitrogen from the air. Phosphorus is critical to cowpea yield because it stimulates growth, initiates nodule formation as well as influences the efficiency of the rhizobium-legume symbiosis. The fertiliser should be thoroughly mixed with soil before placing the seed.

Weed Control. Cowpea should be kept free from weeds in all stages of growth. Timely weeding is absolutely essential. Thorough wedding which reduces the risk of weed spreading and reduces the pest and disease

infestation at the early stages is achieved by a first weeding two weeks after emergence followed by a second wedding three weeks later (just before flowering) in mono- cropping. In intercropping, one weeding three weeks after planting may be sufficient except in high rainfall areas where a second selective weeding three weeks later may be necessary. Care should be taken to avoid damaging the shallow roots especially during the first weeding. Cultivation during flowering time is discouraged, to avoid flower shedding and when the field is wet to avoid spread of diseases and soil compaction.

Pest and Disease Management

Pests (Table 2.6) and diseases (Table 2.7) contribute to reduction in crop yields. The severity varies because of changes in environmental conditions and management practices. Integrated disease and pest management and the use of environmentally safe strategies is recommended.

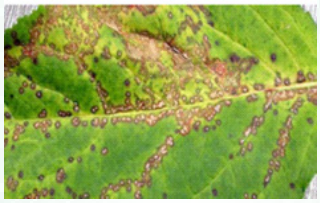
TABLE 2.6. COWPEA PESTS AND MANAGEMENT OPTIONS

Pest	Damage symptom	management
Armyworms (*Spodoptera exigua*)		Hand-picking, crushing or dipping in hot water, Use neem based biopesticides e.g nimbecidine at 50 ml/20 L of water and Spray insecticides e.g Lufenuron Emamectin Benzoate, Lufenuron, Lambda-cyhalothrin, Deltamethrin based insecticides.
Pod-borers		Handpick and destroy the caterpillars and Use bio-pesticides such as Bt or neem based products
Root-knot nematodes		Maintain high levels of organic matter using manure and compost in the soil, Incorporate neem cake powder into the soil, Rotate cowpea with other recommended cross, use biopesticides e.g nimbecidine at 50 ml/20 L of water and Use repellant crops such as marigold
Aphids (*Aphis craccivora*)		Plant early, Destroy and bury infested plant materials to reduce aphid colony in the field , Practice crop rotation, use of sticky traps (blue/ yellow), and yellow water. Spray soapy solution and use overhead irrigation to knock aphids off the leaves.

TABLE 2.6. COWPEA PESTS AND MANAGEMENT OPTIONS

Red spider mites (*Tetranychus spp.*)		Avoid planting next to infested fields, Avoid frequent use of broad-spectrum pesticides, particularly pyrethroids as this may lead to spider mite outbreaks.
Whitefly (*Bemisia tabaci*)		Mount yellow sticky traps to trap adults, Spray with pepper, Conserve natural enemies and parasitoids Drench with imidacloprid based products and Spray lambda-cyhalothrin based products Spray alpha-cypermethrin based products

TABLE 2.7. COWPEA DISEASES AND MANAGEMENT OPTIONS

Disease	**Damage symptoms**	**Management**
Anthracnose *(Colletotrichum lindemuthianum)*		Use certified seed and practise crop rotation with non-legumes, Spray with Flutriafol 125/L based product
Bacterial Leaf Blight *(Xanthomonas phaseoli)*		Destroy infected plant residues and use disease-free seed, Use copper based products
Powdery Mildew *(Erysiphe polygoni)*		Practise early planting, crop rotation with non-legumes for 2-3 seasons Observe high field hygiene, uproot and destroy severely infected plants to reduce inoculum in the field, apply sulphur based protective fungicides

Harvesting and Storage

Dry cowpea should be harvested when the plants turn yellow to light brown and the leaves start to fall off by hand picking the pods since they mature unevenly. Uproot the entire plant when it has reached full physiological maturity. Early-maturing and erect varieties, the pods mature and dry evenly, hence harvesting can be done once by uprooting the entire plant or hand picking. For indeterminate and prostrate varieties, the pods mature and dry unevenly hence the pods should be hand-picked as they mature and dry. Harvesting should be prompt, as delay in harvesting encourages

weevil infestation in the field and seed shattering. If the condition is humid the quality of grains may deteriorate due to mould.

Further Reading

Esilaba, A.O., Nyongesa, D., Okoti, M., Otipa, M. and Lusike Wasilwa. (2021). KCEP-CRAL Cowpea Extension Manual. Kenya Agricultural and Livestock Research Organisation, Nairobi, Kenya.

Mango (*Mangifera indica L.*)

Commercial mango varieties of Kenya (Photo: Lusike Wasilwa)

Mango belongs to the family *Anacardiaceae* with 75 genera and 700 species. It is one of the high potential fruits in Kenya, suitable for different agro-ecological zones ranging from sub-humid to semi-arid. In 2016, this fruit was ranked 2nd in terms of value amongst fruits.Mango is produced for both local and export markets. The country has a huge potential to further increase mango production. However, the quality and quantity of fresh and processed mango cannot adequately meet the demand of both domestic and export markets. Profit of small-scale farmers, who are the main producers of mango, this can however be improved by cultivating the most suitable varieties (Table 2.8) and applying better tree management practices such as integrated pest management (IPM).

Ecological and Site Requirements

Along the Coastal region of Kenya, mango undergoes two main growth flushes, one in May to June and another November to December each year. However, in medium altitude areas, the main growth flush occurs in May to June after the long rains. These growth flushes are followed by flowering about 3 months later

Altitude	Temperature	Rainfall	Soil
0 -1500	24 - 35	>650 mm pa	PH 5.5 – 7.5
		tolerant to drought	Deep well drained, loam or clay, Not too waterlogged, alkaline or shallow constant supply of nitrogen and

TABLE 2.8. MANGO VARIETIES

Cultivar	General attributes
Ngowe	Large and long in size, Excellent flesh and fibre-free, Deep yellow colour, Early season (Jan – Mar), Resistant to anthracnose and its mainly for export. [Hot to low alt. area (0 – 700 m A.S.L)]
Boribo	Long and large fruit size, Deep orange-red flesh and fibre-free, Early season (Jan – Mar), Resistant to anthracnose and mainly consumed locally. [Hot to low alt. area (0 – 700 m A.S.L)]
Apple	Medium and round sized fruit, Bright yellow – orange to red fruit colour when ripe, Excellent flavour, Early season (Dec – Mar), Resistant to anthracnose and mainly consumed locally. [Hot to low alt. area (0 – 700 m A.S.L)]
Batawi	Very large and round sized fruit with green to purple maroon colour, flesh has good texture, little fibre and good flavour, late season (Mid Jan – Mar), Resistant to anthracnose and mainly consumed locally. [Hot to low alt. area (0 – 700 m)]
Tommy Atkins	Juicy red fruit, firm, very sweet and fibreless, tree full and dense Early season (Jan – Mar), Resistant to anthracnose [Low to mid alt. areas (500 – 1500 m]
Van Dyke	- Red fruit, orange-yellow flesh, with scanty fibre, oval shape,Mid-season (Jan – Mar) [Low to mid alt. areas (500 – 1500 m A.S.L]
Kent	Green/red/yellow, soft, sweet and fibreless fruit, large and upright tree, late season (March - April), Resistant to anthracnose. [Low to mid alt. areas (500 – 1500 m A.S.L]
Sabine	Elongated medium size fruit, Moderate-large tree, late season (January - March), Resistant to anthracnose. [Low to mid alt. areas (500 – 1500 m A.S.L]
Keitt	Large fruit, heart shaped, Yellow flesh colour, Moderate size tree, late season (March - April), Resistant to anthracnose. [Low to mid alt. areas (500 – 1500 m A.S.L]

Establishment of a Mango Orchard

The following considerations must be put in place;

- Choice of the proper location and suitable variety
- Arrangement of the orchard; pure stand or where soil is not fertile adopt the spacing of 10 m by 10 m, grafted tree is spaced at 8 m by 10 m or 10 m by 12 m. Mango trees can be grown together with many other plants: as border trees on cultivated gardens, in intercropping within the gardens, in very diverse agroforestry systems or in silvi- pastoral systems (using small animals, such as sheep or goats).
- Planting and management of mango seedlings; Spacing of between 8 – 12 m2 (ideal situation) or 10*10m (dry zones) or 5*3m or 5*2.5m or 3*2.5m or 2.5*2.5m (where high-density planting is required). Prepare the planting holes 1 month before planting to allow for seasoning/withering. Depth of hole should be 1 x 1 x 1 m3 (in shallow & hilly soils) or 0.5*0.5*0.5m (in loamy and deep soils) · Top soil should be separated from the subsoil when digging the holes.
- Transplanting and fertiliser management. Mix topsoil with manure and fertiliser as follows: 1 debe of manure per hole (in the ratio of 1 debe manure to 3 debes of topsoil), About 60g of a compound fertiliser (NPK) e.g. DAP, depending on the fertility of the soiland return the mixture to the hole filling to about 2/3 (two thirds) of the hole.

Remove the polythene sleeve carefully so that the plant can be planted with the entire ball of the soil, Clip the longer roots to avoid bending during transplanting, Place each of the seedlings at the centre of the planting hole, Cover the seedling at exactly the same depth as it was in the polythene sleeve leaving about 6 inches below the soil surface, Once the trees are established (about 3 – 6 months after Planting), start applying nitrogenous fertilisers e.g. CAN as follows:- 1st year 50g CAN/tree, 2nd year 100g CAN/ tree, 3rd year 150g CAN/tree and 4th year 200g CAN/tree. Mulch the base of the transplanted seedling to conserve moisture. Water must be supplied on need basis.

Nitrogen fertilisers should be applied in splits to avoid leaching out.

Pruning. The form and height of a mango tree needs to be controlled to guide the tree and to facilitate harvesting at a later stage

There are two main forms of mango pruning; Formative pruning (It is done in the first years of the young tree to guide the tree into the desired shape) and Structural pruning (should be done for proper maintenance of the trees and should be done mostly after fruit harvest)

- Improving flowering and fruit formation
- Pegging heavy branches; done on heavily loaded varieties or trees to avoid breaking.

Weeding. Remove weeds regularly beneath the mango tree, so as to minimize competition and harbouring "PESTS". This can be done by us chemical, biological, Physical or manually.

- Chemical method: Control weeds in mango orchards by applying herbicide like paraquat (3.0 kg a.i/ha), Diuron as pre-emergent treatment at 6.67 and 8.9 kg/ha. Bromacil and dalapon are herbicides for controlling dicot and monocot weeds respectively.
- Biological control. A common practice of grazing livestock in a well grown and established orchard.
- Physical Method involves the use of plastic mulch, uprooting or use of hand hoe

TABLE 2.9. MANGO PESTS AND MANAGEMENT OPTIONS

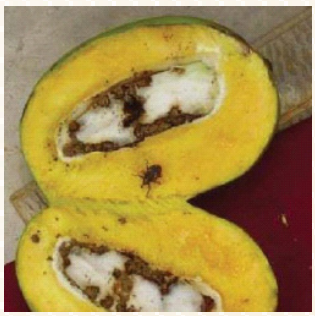
Pest	Appearance/Damage	Management
Fruit fly *(Bactrocera invadens)*		Collect and destroy all fallen fruits at least twice a week during the fruit season, pick overripe fruits as they attract fruit flies, use of physical method like traps and fruit bagging
Mango seed weevil(*Sternochetus mangiferae*)		Keep the orchard clean, apply sticky bands at the upper end of the trunk just before branches, Regular scouting and remove fruits with egg laying marks and destroy them.
Mealy bugs (*Rastococcus Spp*)		Destroy affected parts at the beginning of the infestation, Conserve natural enemies, avoid excessive spraying and the use of broad-spectrum pesticides since they may kill natural enemies, control ants tending mealybugs

TABLE 2.10. MANGO PESTS AND MANAGEMENT OPTIONS

Disease	Damage sign	Management
Powdery Mildew(Oidium mangiferae)		Consider planting appropriate cultivars, weekly monitoring of the disease, spray solutions of baking powder, white oil and white bar soap foam, apply Sulphur based fungicide
Anthracnose(Colletotrichum gloeosporioides)		Plant tolerant varieties, cut out dead branches, twigs and leaves, weekly monitoring of the disease
Bacterial spot(Xanthomonas campestris)		Use appropriate cultivars for specific region, prune off diseased twigs, establish windbreaks around the orchard, spray with copper-based chemical, monitor for the disease weekly
Scab (Elsinoe mangiferae)		Use of cultural practices, genetic plant resistance, certified seeds and chemical control (copper based)

Harvesting

A mango plantation is ready for harvesting in 1 to 6 years after transplanting, depending on the variety, management and the planting material used. Good production is realised after eight years for the non-grafted and reaches full maturity at 20 years of age. One tree should produce 200 to 500 fruits per year and varieties like “Dodo” and “Boribo” can produce 1000 fruits per year. Depending on cultivars and environmental conditions Kenyan mango varieties take 90 to 160 days after flowering to reach maturity. The fruit will have its best flavour if allowed to ripen on the tree. The fruits are generally picked when they begin to change colour. Harvesting is done by hand Picking mature fruits or Clipping them off with a long stalk of about 2 to 3 cm and packing the fruit in a single layer with the stalks facing downwards in the box or crate. It is important that the latex dripping from the stalk drops onto an absorbent material

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Kehlenbeck, K., Rohde, E., Njuguna, J.K., Omari, F., Wasilwa L., Jamnadass, R. (2010). Mango cultivar diversity and its potential for improving mango productivity in Kenya. Horticulture Africa. horticulturalnews@gmail.com

Water melon (Citrullus lanatus)

Water melon crop (Photo: Farmbiz Africa)

Watermelon is a warm season crop that belongs to the cucurbit family (Cucurbitaceae). It is indigenous Popular fruit for fresh consumption and agro-processing, such as juice making that is native to the dry plains of tropical and subtropical Africa. The crop is one of the most widely cultivated crops in the world. Watermelon is a good cash crop with very good market opportunities, particularly in urban areas. The fruit has substantial amounts of food energy, carbohydrates, fats, protein and calcium. A watermelon fruit contains about 6% sugar and 92% water by weight. As with many other fruits, It is a source of Potassium, Vitamin A, Vitamin C, Folate and Amino acid.

Ecological Requirements

Watermelon	Temperature	Rainfall	Soil	Altitude
	20 – 28	400 – 1000 mm pa Excessive humidity may favour leaf diseases and also affect flowering.	PH 6.0 – 6.8 Slightly acid, well drained sandy loam soils	0 - 1500

Varieties

There are over 1200 varieties of watermelons worldwide and a wide variety of watermelons have been cultivated in Africa. Several of these varieties have been recommended for Kenya's climate. These include:

Sugar Baby. Round dark green to black fruit with deep red flesh, Very sweet and juicy, Matures after 120 days, Average fruit weight 4 kg and Yield potential is 20 – 30 tons/acre

Sukari F1. Early to medium maturing, Good fruit setting ability, Fruits are oblong in shape, Rind colour: light green with dark green stripes, Maturity Period is 90 days, Average fruit weight range between 7 – 8 kg, Yield Potential is 25 – 35 tons/acre and has good transport and keeping qualities

Crimson Sweet. Has a light green rind with broad dark green stripes, has blocky oval shaped with brilliant red flesh, Maturity Period is 90 – 120 days, Average fruit weight is 7 – 9 kg, Yield potential 25 – 30 tons/acre and Good shipping quality and resistant to extreme heat and Root-knot Nematodes

Sweet Rose F1. Vigorous with good adaptability, fruits are oval to round, good keeping quality, flesh is deep crimson red with good texture, maturity Period is within 80 – 90 days after transplanting and the average fruit weight is 10 – 12 kg

Charleston Grey. Very elongated and oblong, light green striped variety with red flesh and hard rind, at maturity, rind colour turns to light green, fruits are sweet, juicy and crunchy, ideal for fresh market, tolerant to Fusarium and Anthracnose, drought resistant, maturity Period is 80 – 85 days, average fruit weight: 8 – 10 kg and able

to withstand long transportation

Agronomic Practices

Land Preparation. Land should be prepared early enough so that the field is free of weeds and ready for planting at the onset of rains. The land should be prepared to a fine tilth and levelled so as to enhance moisture absorption & retention, easy germination & root penetration, ensures better surface contact between the seed and the soil and for uniform depth.

Planting. Watermelon is propagated by seed that can be done directly in the field or raised on a nursery before transplanting. Seed Rate is about 0.6 – 1.2 kg per acre depending on variety and spacing. The holes are dug at a distance of about 90 – 100 cm within the row and about 100 – 150 cm between the rows. Plant 2 seeds per hill, placing them 3 to 4 cm (1.5 inches) deep into the soil.. this will give 2,666 - 4,444 plant Population per acre. To hasten germination, Soak seeds overnight

Fertiliser Requirement. Well composted manure should be broadcasted (8 tons per acre) then worked into the soil (incorporated) preferably using a hoe. Alternatively, apply a handful per planting hole before sowing. Manure/compost should be applied 1 – 2 weeks before sowing the watermelon and incorporate into the soil. 80 kg per acre of TSP or DSP. CAN top dressing fertiliser is applied in 2 splits; 1st split application: when the plants start to run (40 kg per acre) and the 2nd split application: when plants are about to flower (80 kg per acre)

Water Management. Water deficit during flowering and fruit development causes serious yield reduction. Irrigation is important to ensure consistent moisture availability. Excessive irrigation makes mature fruits to split / crack, tasteless and watery

Weed Control. Watermelon has a shallow root system therefore care should be taken to avoid bruising the roots during weeding, The frequency of weeding depends on weed infestation; generally keep the field weed-free as much as possible to avoid competition for nutrients, sunlight and moisture. This can be done through use of appropriate weeding tools. Weeding watermelon field when the soil is wet can increase the spread of some bacterial (Bacterial Wilt) and fungal (Fusarium Wilt) diseases

Mulching. It is a recommended crop management practice for Watermelon production. Mulching could be done using straw or dry leaves. Its advantages include; Moisture conservation, Weeds suppression and Prevents fruits from being in contact with soil and thus prevents pest & disease attack. The fruits need to be turned regularly to ensure uniform fruit colour development

Pruning. Remove any dead, diseased, yellowing or infested leaves or shoots at the joint where they are connect to the main stem. Remove deformed and blossom-end rot fruits. Maintain 2-3 vines and remove extra vines. If market demands larger melons leave 3- 4 well shaped melons per plant. Do not prune when vines are wet

Pests

Pest damage causes reduction in quality and quantity of produce. Major pests of Watermelon in Kenya: Melon Fly, Aphids, Spider Mites, White Flies, Epilachna Beetles and Root-knot Nematode (Table 2.11)

TABLE 2.11. WATERMELON PESTS AND MANAGEMENT OPTIONS

Pest	Damage symptom	management
Melon Fly		Field Monitoring/ Biological control Cultural Control Chemical Control, Use of pesticides, such as; Deltamethrinand Trichlorfon

TABLE 2.11. WATERMELON PESTS AND MANAGEMENT OPTIONS

Spider Mites		Adequate irrigation Mulching to conserve water Predatory mite Spray with miticides, such as Bifenthrin
White flies		Use of pesticides such as: Lambda-cyhalothrin Thiamethoxam
Aphids		Ensure plants are not water stressed Use of pesticides, such as Azadirachtin and Deltamethrin
Root-knot Nematode (*Meloidogyne spp*.)		Cultural control Crop rotation Use of resistant varieties Chemical control Use of ethoprophos and azadirachtin

Diseases

Disease infection leads to reduction quality and quantity of produce. Major diseases of watermelon include; powdery mildew, anthracnose, downy mildew, fusarium wilt, Black rot and root-knot Nematodes (Table 2.12)

TABLE 2.12. WATERMELON DISEASES AND MANAGEMENT OPTIONS

Disease	Damage symptoms	Management
Anthracnose		Crop rotation Plant clean seeds Use of fungicides, such as; Copper Oxychloride, Mancozeb and Azoxystrobin + Difenoconazole
Powdery mildew		Use of fungicides, such as Sulphur, Famoxadime+Cymoxanil and Azoxystrobin + Difenoconazole

TABLE 2.12. WATERMELON DISEASES AND MANAGEMENT OPTIONS

Downy Mildew		Cultural Control; Reduce canopy density • Chemical Control; Mancozeb (Milthane Super®, Penncozeb, Propineb + Cymoxanil and Dimethomorph + Mancozeb Crop rotation
Fusarium Wilt		Rouging/removal and destruction of diseased plants Plant in well drained soils and avoid water logging Use of certified seed Use of well decomposed manure and compost

Harvesting Indices

- Tendrils near fruit stem have changed colour from green to brown
- Ground spot on the belly of the melon has changed from white to yellow
- The fruits when thumped with the hand produce muffled dull tone (immature fruits produce clear metallic ringing tone)
- Leave the stalk attached to the fruit
- Mature fruits have sweet flavour, crisp texture and deep red colour
- Sugar content (measured as soluble solids by use of hand held refractometer) of 10 % or more in the flesh near the centre of the melon. Yields: 25,000 – 50,000kg per acre

Main harvesting stages; Mature but before full ripeness for distant markets and Mature and ripe for nearby markets

Notes: Watermelons don't ripen after they are picked so harvest time is important, If harvested immature, red colour will develop but sugar content does not increase after harvest and Harvesting should be done by cutting the vine and NOT pulling, twisting or breaking off the vines

Further Reading

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Capsicum/ bell pepper (Capsicum annuum)

Green and red Capsicum Photo Source: SHEP PLUS

Capsicum/bell pepper, also called sweet pepper. It is a horticultural vegetable crop that belongs to the family Solanaceae . It has a mild flavour, not hot and rich in vitamin A and C with natural elements such as Potassium and Phosphorous

Ecological requirement

The ideal growing conditions for capsicum include, altitude range of 0 – 2000 metres above level, rainfall of between 600 – 1200 mm p.a, temperature range 0f 18 – 30 ^{O}C. The crop does well on well drained loamy soils with PH of 5.5 – 6.8 and high in organic matter content.

Varieties

There are two main types: determinate (open field) and Indeterminate (greenhouse) varieties.

- Determinate varieties: are bushy with defined growth and development period. Examples include Yolo Wonder and California Wonder
- Indeterminate varieties: achieve growth through a single apical stem with few secondary branches. Examples Commandant F1, Admiral F1, Nemalite F1, Green Bell F1

California Wonder is:

- Suitable for home and market gardening
- Fruits are thick walled, 4 lobed, blocky and compact
- Yield: 6,000kg per acre

Yolo Wonder

- A popular variety for export and local market
- Fruits are shiny dark green, 3 – 4 lobed, firm and blocky
- It is vigorous, compact and high yielding
- Yield: 6,000kg per acre

Commandant F1

- Grown both in open field and greenhouse

- Resistant to Potato virus, Tomato mosaic and Tobacco mosaic, pepper mild mottle and bacterial spot
- Has long harvesting period: 10 weeks and 4-6 months for open field & greenhouse, respectively
- Fruits can be harvested green (75 days) or red (90 days)
- Yield: 25,000kg-30,000kg per acre (open field), 50,000- 60,000kg per acre (green house)

Admiral F1

- Can be grown in open field and greenhouse
- Has similar characteristics to Commandant F1
- Fruits can be harvested green (75 days) or yellow (90 days)
- Yield: 25,000-30,000kg per acre (open field), 50,000- 60,000kg per acre (green house)

Agronomic Practices

Land Preparation. Land should be prepared early enough so that the field is free of weeds and ready for planting at the onset of rains. The land should be prepared to a fine tilth and levelled so as to enhance moisture absorption & retention, easy germination & root penetration, ensures better surface contact between the seed and the soil and for uniform depth.

Planting. The crop is normally raised in nursery before transplanting to the main field but it can also be directly sown. Nursery for capsicum should be selected/sited in an area that has not been planted with the crop from the same family at least not less than 2 years and should be well drained. Seedlings are ready for transplanting when they are at 4 -6 true leaf stage or 6 – 8 weeks after transplanting. The recommended spacing is 60 cm X 45 cm or 70 cm X 30 cm depending on the variety

Fertiliser Requirement. The choice, type and amount of fertiliser for use will depend on the soil analysis report. The recommendation is to apply 100kg per acre of DSP/TSP during transplanting. It should be mixed well with the soil to avoid scorching and burning of the roots. Top dressing should be done with organic and inorganic/ chemical fertilisers to produce high yields but the general recommendation is that; 1st top-dressing to be done with 40 kg per acre of CAN 2 – 3 weeks after transplanting and the 2nd top-dressing is done with 80 kg per acre of CAN 4 – 6 weeks after transplanting. During flowering high amounts of nitrogenous fertiliser should be avoided

Training and Staking. To keep the plant upright and also keep the fruit clean by avoiding contacts with the soil. It keeps canopy intact and preventing fruits from sunscald, holds heavy loaded fruit to avoid splitting/breaking out from the stem and minimise lodging

Weeding; It is a critical practice that needs to be timely done during the vegetative growth stages of the crop. it should start 3 weeks after transplanting to minimise competition and harbour other pests

Pests

Major insect pests are; White Fly, Root-Knot Nematode, Aphid, Cutworm, Spider Mite, Fruit Borer, Leaf Miner and Thrips. Their management include:

- Use traps like sticky traps
- Conserve natural enemy
- Spray with the recommended pesticide
- Practice Crop rotation and mixed cropping
- Timely weeding and field hygiene
- Routine scouting of the crop field

Diseases

Major diseases of Capsicum; Damping-off, Anthracnose, Leaf Spot, Fusarium Wilt, Powdery Mildew, Viral Diseases, Bacterial Soft Rot, Bacterial Wilt and Blossom End Rot. Their managemnet include:

- Proper site selection
- Growing of certified seeds
- Proper water management
- Spray with the recommended chemical
- Practice good field sanitation
- Practice proper soil fertility management and crop rotation
- Management of the vector

Harvesting

Maturity period ranges between 2-3 months after transplanting. Harvesting can be done at harvestable-green colour or when they have developed full colour. Green fruits are incapable of ripening after removal from the plant. The right stage for coloured fruit is when they have reached full colour, filled out, still firm, sticky and thick walled. Care should be taken during harvesting Since Capsicums have soft pliable thin flesh. Use clean knife or scissors to harvest the fruits. Fruits should be harvested early in the morning when it is cool since the fruit temperature is low. Harvested fruits should be kept in a cool, shaded and ventilated area in order to minimise heat gain. Yield ranges: 6,000 to 60,000 kg/acre depending on the variety and crop husbandry

Further Reading

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Tomato (*Solanum lycopersicum L.*)

Tomato fruits Photo source: Farmbiz Africa

Tomato is one the most produced and consumed vegetables. It belongs to the solanaceae family. It is an important cash crop for smallholder farmers and is produced both in open fields and in the greenhouse. Tomatoes are consumed raw in salads, used in cooking, processed to jams paste and juice.

Varieties

Rio Grande

- Determinate
- Fresh market and processing variety
- Plant is slightly bushy and can be staked or left unstaked

- Tolerant to verticillium and fusarium wilt
- Maturity Period: 75 – 85 days after transplanting
- Yield: 18,000kg per acre

Assila F1

- Determinate early maturing (75 days) variety
- Tolerant to Tomato Yellow Leaf Curl Virus (TYLCV) and nematodes
- It produces fruits with attractive red colour with oval shape & heavy sweet fruits
- Yield: 23,000kg per acre
- Good keeping quality & transportability

Kilele F1

- Determinate type Medium - early maturing variety
- Suitable for drier or humid areas
- Disease tolerance: Tomato Yellow Leaf Curl Virus, Tomato Mosaic Virus, Verticillium, Fusarium Wilt and Nematodes
- Fruits: Firm and elongated and has shelf life of 21 days
- Maturity Period: 75 days after transplanting
- Yield: 30,000 – 35,000 per acre

Cal J

- Open pollinated determinate variety
- Tolerant to verticillium and fusarium wilts
- The plant produces red blocky shaped fruits
- The fruits store and transport well
- Maturity Period: 75 - 85 days after transplanting
- Yield: 11,000 – 13,000kg per acre

.Eden F1

- Determinate and vigorous growing variety
- Good tolerance to Alternaria Canker, Verticillium Wilt, Fusarium Wilt, Nematodes and Bacterial Speck
- Deep red blocky fruits have long shelf life
- Maturity Period: 75 days after transplanting
- Yield: 40,000-50,000kg per acre (9 – 10 kg per plant)

Rambo F1

- Determinate, vigorous plant with uniformly set and firm fruits
- Tolerance: Bacterial wilt, Bacterial spot, Fusarium wilt, Verticillium wilt and Nematodes
- Maturity 75 days after transplanting
- Yield: 30,000kg per acre
- Good shelf life and transport quality

Anna F1

- Hybrid and indeterminate fresh market variety that produces blocky oval red fruits that have a long shelf life,

tolerance to Fusarium, Verticillium Wilt, ℃℃℃Alternaria Stem Canker and Nematodes

- Ideal greenhouse Tomato
- Maturity Period: 75 days after transplanting
- Yield: 64,000kg per acre (18 kg per plant for 8 months)

Ecological requirements

- 0-2000 metres above sea level
- Over 600 mm annual rainfall in open field
- Day temperatures of 20-25℃ and 15-16 ℃ at night
- Well drained sandy loam and clay loam soils

Nursery establishment

- The nursery site should be at a place where other solanaceae crops have not been grown before
- A nursery bed should have a width of 1metre and of convenient length
- Drills should be made 10- 20cm apart
- Seeds should be thinly sowed and covered lightly with soil
- The nursery should be watered regularly and the seedlings hardened 1-2 weeks before transplanting
- Insects such as whiteflies can transmit viruses to young tomato plants hence should be controlled using pesticides e.g. Amitraz (Mitac 20EC®), Buprofezin (Applaud 40%SC®), Azadirachtin (Nimbecidine®), Imidacloprid (Confidor 70 WG®)
- These insects can be blocked from reaching the seedlings by use of an insect proof net (agricultural type)

Transplanting

- Seedlings are transplanted 30- 45 days after sowing
- Transplanting should be done early in the morning or late in the evening
- The spacing should range from 70-100 cm between the rows and 40-60 cm between seedlings depending on the variety
- Apply 2 – 3 handfuls of manure per planting hole (8 tons/acre)
- Apply 2 bottle tops (10 g) of Triple Super Phosphate (TSP) per planting hole (80 kg/acre Apply Muriate of Potash (MOP) to enhance availability of potassium

Tomato Management Practices

- Training and staking- indeterminate varieties should be staked to facilitate pruning harvesting and other cultural practices. Staking is done using strings and wooden or bamboo stakes
- Determinate varieties could be trained in the wet season or mulched to prevent the fruit from touching soil
- Pruning should be done for the indeterminate varieties extra shoots and flowers should be removed to improve quality, increase tomato size and promote early maturity

Tomatoes are attacked by different pests (Table 2.13) and diseases (Table 2.14).

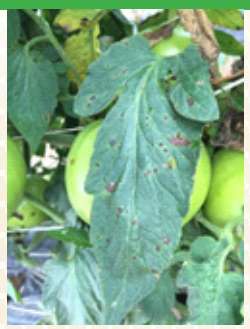
TABLE 2.13. TOMATO PESTS AND MANAGEMENT OPTIONS

Pest	Symptoms	Management
Tobacco Whitefly *Bemisia tabaci*		-Keep tomato fields weed-free -Use of yellow sticky traps to monitor their population levels Cover -omato seedling nurseries with nylon nets or insect proof nets to protect seedlings from Whitefly infestations -Use of insecticides; Amitraz,Buprofezin, Azadirachtin, Imidacloprid, Lambda Cyhalothrin, Lambda, cyhalothrin + Thiamethoxam
Tuta absoluta		-Early control is important before the pest pressure builds up -Carry out cultural practices like field hygiene, crop rotation -Carry out regular scouting/monitoring of pest population -Use of pheromone traps to attract male insects for both monitoring/surveillance and pest control e.g.) mating disruption, mass trapping 'lure &kill' method, such as Tutak traps -Use of biological control agents, such as - Chlorantraniliprole, Indoxacarb, Spirotetramat + Flubendiamide, Thiocyclam 50% w/w; Thiocyclam-hydrogen oxalate and - Imidacloprid, Flubendiamide (Belt 480SC®) -The above pest control tactics should be combined in an IPM strategy
African bollworm *Helicoverpa armigera*		-Tilling and ploughing of old tomato field exposes pupa to desiccation and natural enemies -Planting of trap crops (Cucumber, Maize and mexican Marigold) which attract the pest before it attacks tomatoes (Need to synchronise planting of both maize and tomatoes so that they flower at same time) -Use of selective pesticides, such as microbial control agents: – Helicoverpa armigera NPV Virus (Helitec SC®) – Indoxacarb (Avaunt 150SL®) – Etofenprox 30%(TREBON 30 EC®)

TABLE 2.14. TOMATO DISEASES AND MANAGEMENT OPTIONS

Disease	Symptoms	Management
Late Blight *Phytophthora infestans*		-Crop rotation -Removal of all volunteer crops that are more susceptible to this disease -Pruning and staking in order to improve air circulation and reduce humidity -Use of fungicides, such as: – Metalaxyl + Mancozeb (Ridomil Gold MZ68®), Propineb + Cymoxanil (Milraz WP76®), Mancozeb (Dithane M45®), Dimethomorph + Mancozeb (Acrobat MZ®)

TABLE 2.14. TOMATO DISEASES AND MANAGEMENT OPTIONS

Early Blight *Alternaria solani*		-Use of certified seeds -Appropriate spacing -Avoid overhead irrigation, water in the morning and keep plants healthy/ stress-free -Use of fungicides, such as; Chlorothalonil (Odeon® 82.5WDG), Manconzeb (Oshothane®), Propineb (Antracol WP70®), Mancozeb + Cymoxanil (Agromax®), Propineb + Iprovalicarb (Melody Duo®) -Practice crop rotation with crops such as cereals
Bacterial wilt		-Remove wilted plants, with the soil around roots, from the field and destroy -Solarize planting beds -Spot treatment with Sodium Hypochlorite at 10 % dilution (Jik) or with lime/ ash -Sterilise pruning tools -Use of Metam sodium (METHAM SODIUM 51 Liquid soluble®), Bronopol (ENRICH BM Wettable Powder®) -Use resistant tomato varieties (e.g. “Fortune Maker”, “Rio Grande”, “Tengeru 97”, “Roma VFN“, “Eden F1”, “Rambo F1”, “Anna F1”).
Fusarium wilt		-Use certified disease-free seeds. -Do not locate seedbeds on land where Fusarium wilt is known to have occurred. -Where soil is acidic, raise the pH by applying lime or farmyard manure -Avoid excessive nitrogen fertilisation and control root-knot nematodes.

Harvesting and Handling

- Maturity period ranges between 3-4 months after transplanting depending on: – The variety – Environmental conditions
- Tomato can be harvested at different stages depending on the market requirement and distance to the market
- There are four (4) main harvesting stages: – Mature-Green Stage: where the fruit is green but internal gel is well developed – Breaker/turning Stage: up to 30 % of fruit surface has definite colour break from green to yellow – Pink/Light Red Stage: 30 – 90 % fruit surface has pink/red colour – Red/Ripe Stage: over 90 % fruit surface has changed to red colour
- Fruits should be harvested early in the morning when it is cool since the fruit temperature is low
- Harvested fruits should be kept in a cool, shaded and ventilated area in order to minimize heat gain
- Where necessary, wipe fruits to remove dirt
- The yields vary from 12,000 – 40,000kg per acre depending on the variety and crop husbandry

Further Reading

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East African Seed Co. Ltd. Africa's Best Grower's Guide www.easeed.com

Onion (*Allium cepa*)

Onion crop (Photo: Farmbiz Africa)

Onion is an important spice crop and it can be eaten raw or cooked. Onion is rich in Calcium, Iron, Potassium, Vitamin B6 and B9, Vitamin E and has medicinal properties

Varieties

Red Creole

- A popular variety which produces red, flat-round, globular bulbs
- It has very pungent taste
- Matures 150 days after transplanting
- Excelle storage qualities
- Yield Potential: 16,000kg per acre

Bombay Red

- This variety is suitable for dry and warmer conditions
- Produces small to medium sized bulbs, which are globe shaped, Deep purple red colour and very pungent
- Matures 150 days after transplanting
- Yield Potential: 16,000kg per acre
- Tropicana F1
- Very productive and produces large red, thick flat bulbs with firm pungent taste
- Yield Potential: 25 tons per acre
- Maturures 90 -100days after transplanting

Texas Grano

- White colour with golden exterior
- The bulbs are relatively larger

- Matures 120 days from transplanting
- Does not have good storage qualities.
- It has mild pungency, which is good for salads
- Yield: 21,000kg per acre

Red Pinoy F1

- Deep red attractive bulbs
- Matures 90 days from transplanting
- Strong pungency
- The variety has a long shelf life of up to 6 months at room temp
- Tolerant to Downy Mildew and Purple Blotch
- Yield: 30 tons per acre

Ecological Requirements

- Onion can be cultivated up to 1,900 m above sea level
- Requires well-distributed rainfall of between 500 and 700 mm during the growing period.
- A dry spell is needed at maturity.
- The optimum temperature for growth is 15 – 30 0C. If the temperature exceeds 30 0C, maturity is hastened & small bulbs are produced, consequently lowering the yields. When the temperature is low, growth is slowed or the plant may result in flowering. Cold weather is also associated with increased leaf diseases.
- Requires fertile and well-drained soils.
- The optimum pH range is 6.0 – 6.8. Sandy to silty loams with fine tilth are adequate.

Nursery Establishment and Management

- Prepare beds maximum 1 m wide and incorporate well-decomposed compost /FYM 20 kg/m2 and add DAP/ TSP 20 g/m2
- Make rows about 15 cm apart, drill the seed thinly in 1cm furrows and cover lightly with soil and mulch
- Germination takes 7-10days

Transplanting

- Seedlings are transplanted 6 – 8 weeks after sowing or at 3-5 well formed leaves when base is pencil thick
- The seedlings are transplanted in 2.5 – 3 cm deep trenches at a spacing of 30 cm between rows and 8 – 10 cm between plants (when using furrow irrigation)
- Apply 80 kg/acre of TSP
- Irrigate field well a day before transplanting
- Carefully pull out the seedlings to avoid damage
- Cut off 50 per cent of the green tops to hasten take off
- When planting onion sets, don't bury them more than one inch under the soil

Management Practices

Topdressing

- Top-dressing can be done in 2 splits
- 1 st topdressing: 30 days after transplanting at 40 kg/acre of CAN
- 2 nd topdressing: 45 days after transplanting at 80 kg/acre of CAN
- Strip/banding method is preferred over broadcasting as it is more effective
- Too much nitrogen results in thick necks
- Top-dressing should be completed before initiation of bulbing

Unearthing

- Unearthing is removal of excess soil around the bulb/loosening soil to allow the bulb to expand or develop well
- Unearthing can also facilitate the colouring and curing
- If the soil is hard during bulb formation, loosen the soil to allow bulbs to develop well
- Unearthing is carried out during 2nd and subsequent weeding and is done by removal of the soil from the bulbs by hand
- Watch out not to damage or expose the roots

Onions are attacked by different pests (Table 2.15) and diseases (Table 2.16).

TABLE 2.15. ONION PESTS AND MANAGEMEMNT OPTIONS

Pest	Symptom	Management
Onion thrips		-Keep plants well irrigated since water stressed plants are more susceptible to thrips damage -Maintain weed-free plots -Rogue heavily infested plants -Neem extracts can be sprayed on attacked plants -Spray with insecticide, such as **Spinosad (Tracer®), Abamectin + Acetamiprid (AMAZING TOP 100 WDG® PHI:21days), Acephate (ASATAF SP® PHI: 3-7days)**
Onion Flies		-Practice crop rotation -Use well decomposed manure/compost -Practice field sanitation: remove and destroy infested plants -Carefully plough in crop residues immediately after harvest

TABLE 2.16. ONION DISEASES AND MANAGEMENT OPTIONS

Diseases	Symptom	Management
Downy Mildew		-Field hygiene -Crop rotation -Use tolerant varieties e.g. Red Pinoy F1 -Use of fungicides e.g.) **Mancozeb (Cadilac®, Dithane M45® etc.)** -Use resistant varieties e.g. Red Passion F1 and Red Pinoy F1 • Crop rotation -Field Sanitation: remove crop remains after harvest, do not leave volunteer plants in the field Avoid over fertilisation
Purple Blotch		-Use- recommended spacing and good drainage to decrease humidity in the plant stand -Use of fungicides such as **Mancozeb (Dithane M45®) Difenoconazole (Domain 25% EC®), Propineb + Cymoxanil (Milraz WP 76®) Eugenol (e.g. Explorer 0.3 SL®)**

TABLE 2.16. ONION DISEASES AND MANAGEMENT OPTIONS

Onion Rust		-Crop rotation -Application of proper agronomic practices: proper nutrition and spacing -Use of fungicides: – **Mancozeb (Dithane M45) – Difenoconazole (Domain 25% EC®) □ Eugenol (Explorer 0.3 SL®)** -Use fungicide treated seeds or sets -Avoid damaging onion bulbs at or during harvest -Don't bend over foliage to hasten drying out -Only harvest onions when the necks have ripened and fallen over on their own accord.
Neck Rot		-Avoid using high nitrogen fertilisers -Crop rotation at least 3 years -Dry the bulbs out thoroughly after harvest -Good ventilation is more important in the drying process than the sun. -Store only bulbs with dried out thin necks -Store bulbs in a cool and dry place -Sort out bulbs which show signs of rot.

Harvesting and handling

Harvesting indices. Harvesting can be done 90-150 days after transplanting depending on the variety. Bulb Onions are ready for harvesting when the leaves collapse or when 75% of the tops of the crop have dried and fallen over. Leaf tops begin to discolour, bend and dry towards the ground. Reduced thickness of sheath leaves surrounding the bulbs.

Curing. Curing is a process intended to dry off the necks and outer leaves of bulbs. The main objective is to prolong shelf life by preventing moisture loss and attack by diseases. It can be done in the field or in a protected environment away from adverse weather conditions, such as rain or direct sunlight.

Field Curing. Curing can be done in the field if the maturity and harvesting coincides with dry months. Harvested onions are placed in rows with leaves partially covering the bulbs to prevent sunburn or greening. Onions are then left in the field until the outer leaves and neck are completely dry and papery. Field curing can take 2 – 3 weeks depending on the environmental conditions.

Protected Curing. Curing is done in a warm, dry and well-ventilated location protected from direct sunlight and rain. The process involves removal of excess soil (trimming of foliage leaving 2.5cm of section of stem at neck – Placing onions in single layer in large flat tray)

Onions can also be cured by tying tops of bulbs in bunches and hanging on a horizontal pole in well ventilated shade

Further Reading

Ministry of Agriculture and Rural development and Japan International Cooperation Agency. (2000). Local and Export Vegetables growing Manual. Agricultural Information Resource Centre, Nairobi, Kenya

CAB International. (2005). Crop Protection Compendium, 2005 Edition. Wallingford, UK. www.cabi.org

2.3.2 SUB-MODULE 2: SELECTED CROPPING SYSTEMS AND TECHNOLOGIES

Introduction

A cropping system refers to the type and sequence of crops grown and practices used for growing them. It encompasses all cropping sequences practised over space and time based on the available technologies of crop production. Cropping systems are an important part of sustainable agricultural production.

Cropping systems and technologies commonly practised include:

Organic Farming

Organic agriculture is an integrated production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity. It emphasises the use of natural inputs (i.e. minerals and products derived from plants) and the renunciation of synthetic fertilisers and pesticides.

The organic agriculture techniques are known to be ecologically sustainable by:

- Improving soil structure and fertility through the use of crop rotations, organic manure, mulches and the use of fodder legumes for adding nitrogen to the soil fertility cycle.
- Prevention of soil erosion and compaction by protecting the soil planting mixed and relay crops.
- Promotion of biological diversity through the use of natural pest controls (e.g. biological control, plants with pest control properties) rather than synthetic pesticides which, when misused, are known to kill beneficial organisms (e.g. natural parasites of pests, bees, earthworms), cause pest resistance, and often pollute water and land.
- Performing crop rotations, which encourage a diversity of food crops, fodder and under-utilised plants; this, in addition to improving overall farm production and fertility, may assist the on-farm conservation of plant genetic resources.
- Recycling the nutrients by using crop residues (straws, stovers and other non-edible parts) either directly as compost and mulch or through livestock as farmyard manure.
- Using renewable energies, by integration of livestock, tree crops and on farm forestry into the system. This adds income through organic meat, eggs and dairy products, as well as draught animal power. Tree crops and on-farm forestry integrated into the system provide food, income, fuel and wood.

Conversion to Organic Agriculture

Conversion to organic agriculture describes the process of learning and implementation of changes on the farm towards a more sustainable and natural way of farming. The form the process takes depends on the local circumstances and the predisposition of the farmer or the community, and it varies from farm to farm.

The conversion from a conventional to an organic system requires a transitory period, where the organic practices are applied progressively following an organised plan. During this period, it is important to analyse carefully the actual situation of the farm and identify the actions to be taken

The analysis of the farm must include;

- Farm characteristics: size, plots and crops distribution, which kind of crops, trees, animals are integrated in the farm system.
- Soil Analysis: an evaluation of the soil structure, nutrient levels, organic matter content, erosion level, and/or the soil have been contaminated.
- Climate: rainfall distribution and quantity, temperatures, frost risks, humidity.
- Organic matter sources and management (manures).
- Presence of animal housing systems and/or machinery.
- Limiting factors such as capital, labour, market access, among others.

Processes that aid in the conversion process include:

- Diversify the farming system: Select appropriate annual crops for the area and rotate them in a planned sequence. Include legume crops such as beans or leguminous feed crops in the rotation to provide nitrogen to the subsequent crops. Plant hedges and flower strips to encourage natural enemies and to control pests.
- Start recycling valuable farm by-products. Establish on-farm compost production based on harvest residues and manure, if available, and mix the compost with the topsoil. This will bring stable organic matter into the soil and improve its structure and its capacity to feed the plants and store water. Green manures can provide plenty of plant material to feed soil organisms and build up soil fertility.
- Introduce farm animals into the system. Farm animals provide valuable manure and diversify farm income through additional animal products.
- Grow cover crops. Cover crops or lay out mulches in perennial crops provide protection to the soil.

Intercropping

Intercropping is a cropping system that involves Growing of two or more crops simultaneously in alternate rows or otherwise in the same area, where there is significant amount of inter crop competition.

Intercropping can be done in different ways including;

- Broadcasting the seeds of both crops, or dibbling the seeds without any row arrangement. This is called mixed intercropping. It is easy to do but makes weeding, fertilisation and harvesting difficult. Individual plants may compete with each other because they are too close together.
- Planting the main crop in rows and then broadcasting the seeds of the intercrop (such as a cover crop).
- Planting both the main crop and the intercrop in rows. This is called row intercropping. The rows make weeding and harvesting easier than with mixed intercropping.
- A possible problem is that the intercrop may compete with the main crop for light, water and nutrients. This may reduce the yields of both crops.

Relay Cropping

Relay cropping is a method of multiple cropping where one crop is seeded into standing second crop well before harvesting of second crop. Relay cropping is a sustainable approach that optimises system productivity and compensates yield of two crops at a time and can solve time contravention among sowing of different crops.

Relay cropping has still been recognized, especially by smallholder farmers, because of its potential to increase land use efficiency and reduce fertiliser consumption enhance crop yield and nutrient accumulation, and improve biological activities

Advantages of Relay Cropping include

- It possesses the capability to improve soil quality
- increases net returns and land equivalent ratio
- Helps in the control of weed and pest infestation thereby decreasing chemical pest control measures
- Relay cropping facilitates the farmers to cultivate two crops in 1 year especially in those areas/cropping systems where the growing season is shrinking for sequential farming due to climate change
- Environmental benefits associated with relay cropping include improved soil, air, and water quality by reducing the leaching, emanations, and eutrophication of nutrient compounds.

Crop Rotation

Crop rotation means changing the type of crops grown in the field each season or each year. It is a critical feature of all organic cropping systems, because it provides the principal mechanisms for building healthy soils, a major way to control pests, weeds, and to maintain soil organic matter.

Benefits of Crop Rotation include:

It improves the soil structure; some crops have strong, deep roots. They can break up hardpans, and tap moisture and nutrients from deep in the soil. Others have many fine, shallow roots. They tap nutrients near the surface

and bind the soil. They form many tiny holes so that air and water can get into the soil.

It increases soil fertility. Legumes (such as groundnuts and beans) fix nitrogen in the soil. When their green parts and roots rot, this nitrogen can be used by other crops such as maize. The result is higher, more stable yields, without the need to apply expensive inorganic fertiliser.

It helps control weeds, pests and diseases. Planting the same crop season after season encourages certain weeds, insects and diseases. Planting different crops breaks their life cycle and prevents them from multiplying.

It produces different types of output. Growing a mix of grain, beans, vegetables and fodder means a more varied diet and more types of produce to sell.

It reduces risk. A single crop may fail because of drought. It may be attacked by pests. Or its market price may be low when time comes to sell it. Producing several different crops reduces these risks.

Selecting Crops in Cropping System

Choosing the right crops and crop combinations. Factors to consider when choosing the right crop combinations for a cropping system include;

What does it produce? Crops produce many different things: food, fodder, firewood, fence poles, thatch and medicines. Farmers grow some crops (such as cotton) only for cash. For other crops, such as cereals or vegetables, you may be able to sell what you do not use yourself. Make sure there is a market for the output.

Will it grow well?. This depends on many things: the amount of rain or moisture in the soil, the season (some crops and varieties do not grow well at certain times of year), the soil fertility, and so on.

What inputs are needed?. How much work does it take to grow the crop? Can you get seed? Do you need other inputs, such as fertiliser or insecticide?

What are the roots like?. Tall cereals (millet, maize, and sorghum), finger millets and some legumes (e.g., pigeon pea) have strong roots that penetrate deep into the soil – up to 1.2 m for tall cereals. Their roots improve the soil structure and porosity, so are a good choice if the soil is compacted

Does it improve soil fertility?. Legumes improve the soil fertility by fixing nitrogen from the air. They use part of it for their own needs, and leave the rest in the soil. Cereals and other plants can use this nitrogen if they are intercropped with the legume, or if they are grown as the next crop in the rotation.

Does it cover the soil well?. Tall cereals do not cover the soil well because they have upright leaves and they are planted far apart. Short grasses (Brachiaria, Andropogon) and many legumes (lablab, groundnut, cowpea, and beans) cover the ground very quickly after they are planted. When their main use is indeed to provide cover, we call them cover crops. If their main use is to provide food, we call them food legumes (beans, groundnuts). Does it work with other crops? Try to find combinations of crops that complement each other well. For example, cereals grow well with legumes (either food legumes or cover crops): the cereals benefit from the nitrogen fixed by the legume. Two different legumes or two different cereals do not usually work well together.

Grouping of Crops in a Crop Rotation Program. Generally, the crops are grouped based on their feeding habits and their belonging to a crop family. Most vegetable small-scale farmers in Africa distinguish 4 categories of vegetables. These are botanically based, but also consider the crops' nutrient requirements.

- Leaf crops or high feeders: broccoli, cabbages, cauliflowers, kales, spinach, etc.
- Fruit crops or medium feeders: chilies, egg plants, peppers, tomatoes, etc.
- Root crops or low feeders: carrots, beet roots, potatoes, onions, radishes, turnips, etc.
- Legumes: beans, chickpeas, cowpeas, grams, peas, pigeon peas, etc.

Kitchen Garden

Kitchen garden is the growing of fruits and vegetables at the backyard of house by using kitchen waste water.

Otherwise called as Home garden or Nutrition garden or Kitchen gardening or Vegetable gardening

Advantages of Kitchen Garden include:

- Supply fresh fruits and vegetables high in nutritive value
- Supply fruits and vegetables free from toxic chemicals
- Help to save expenditure on purchase of vegetables
- Vegetables harvested from home garden taste better than those purchased from market
- Effective utilisation of kitchen waste water and kitchen waste materials
- Exercise to the body and mind

Kitchen gardens are best suited at the backyard of house and in open areas with plenty of sunlight near the water source

There are different types of kitchen gardens including

The wick irrigation garden. This is a simple garden that employs the use of jerry cans and a wick measuring 30cm long and 2cm in width. The wick – much like with a kerosene lamp – draws water up to the soil where the crop is growing. The can is sliced in such a way the lower half holds water in which the wick is dipped and the upper half holds the soil, the plant and the wick. Most medium-sized vegetables like spinach and cabbages would do well in a wick garden. Mounted on a wooden frame, the wick garden would easily fit in any amount of space.

Tyre garden. Do you have used car tyres of any size? If you do, do not worry about how to dispose of them. Cut the tyre to remove the inner rims on both sides. Place it on the ground to form a circle and fill it with soil and manure. The tyre garden can be used to grow herbs like rosemary, fruits like strawberry and vegetables like kales.

Simple drip irrigation garden. With used plastic containers and a wall (or a pole) one can establish a simple drip irrigation garden. The best containers would be 5-litre jerry cans. The cans are cut in such a way they would be easy to fix on the wall or a pole and placed vertically one above another. At the top of the cans, a water-holding container with a hole at the bottom – from which water would drip when the cover is open – is erected and operated.

Micro garden. The micro garden is simple to develop and best suited for city dwellers with nothing much than a balcony to grow food. It involves use of plastic containers like buckets to carry soil and manure. One can hang the buckets from the balcony ceiling or just arrange the buckets on the floor. The micro garden is watered regularly based on the crop's water needs.

The Multi Storey Garden. This garden uses sacks and nets. One can also improvise with linen shaped like sacks. Holes with diameters measuring about 3cm are cut out and properly spaced on the sack. Soil mixed with manure is then placed in. Ballast (or medium sized stones) is stacked at the centre of the sack to form a midrib through which watering will be done. The sack is pulled up until it is full and upright. Vegetables – especially spinach and green collard (sukuma wiki) – are transplanted from a nursery into the holes on the wall of the sack and a few at the top.

Further Reading

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2.3.3 SUB-MODULE 3: INTEGRATED PEST AND DISEASE MANAGEMENT (IPDM)

Introduction

A pest is any organism/species, strain that causes injury to plants and plant products or animals and or spreads diseases. Integrated Pest Management is a pest techniques considering all potential pests of a crop and pesticides are only applied when it is absolutely necessary concepts of IPM encompassed in this definition include;

- is not a "package" but is location specific (even down to the field level or crop growth stage), is a combination of all suitable techniques
- must be considered as an integral part of crop production together with all agronomic techniques (ie integrated crop management – ICM),
- considers the economics of pest management,
- optimises pesticide use, eliminates unnecessary use of pesticide, and promotes safe handling and application for the protection of health and the environment – as little as possible, as much as necessary.

Principles of IPM

- IPM is made up of six principles that make pest management sustainable, they include;
- **Prevention:** This includes practices that prevent the entry and establishment of a pest into a crop area. it includes practices such as field sanitation, and planting certified seeds
- **Identification:** Pests their hosts and natural enemies should be identified before any action is taken
- **Monitoring:** Monitoring guidelines should be established to ascertain what pests are present and at what populations. scouting regularly for pests and diseases is recommended
- **Action Thresholds:** action thresholds for different pests in different crops should be established to prevent economic injury especially in high value crops
- **Implement Control tactics:** once the action thresholds have been established the different control tactics can be utilised in the management of the pest or disease
- **Monitor evaluate and document the results:** the results of the management and or control tactic should be documented to evaluate its efficacy and the improvement practices and tactics that can be employed

The major components of IPM in increasing order of complexity are as follows;

Cultural methods. Cultural methods include regular farm operations that either destroy pests or prevent them from causing economic loss. this includes but is not limited to;

- planting certified seeds
- roguing infected plants
- intercropping to improve plant nutrition
- crop rotation
- early harvesting
- early planting

Mechanical/ Physical methods including:

- Removal and destruction of egg masses, larvae, pupa and adults of insect pests and diseased plant parts whenever possible
- Use of insect traps
- Flooding
- Use of pheromones to disrupt mating and for mass trapping
- Use of forceful irrigation water to dislodge insects

Regulatory Practices. These are practices that are enforced by a government regulatory body such as KEPHIS (in the kenyan context), under which seeds and infested plant materials are not allowed to enter the country or from one part to other parts of the country. These are known as quarantine methods and are of two types i.e. domestic and foreign quarantine.

Biological Methods. Biological methods involve the use of living organisms to control unwanted organisms. Biological pest and disease control is based on the principle that all living organisms have a natural predator that keeps their populations in check. Organisms used in biological control include;

- **Parasitoids-** organisms that lay eggs on the bodies of their hosts, when the eggs hatch they kill the host for example parasitic wasps in the control of aphids
- **Predators**- these are free living organisms that prey on other organisms for food examples include dragonflies, spiders and lady bird beetles
- **Biopesticides**- these are microorganisms that infest the host causing diseases and eventually killing the host. Pathogens used as biopesticides include fungi, viruses, bacteria and some nematodes. Examples of biopesticides commonly used include *Beauveria bassiana* in the control of termites and whiteflies, *Metarhizium anisopliae* used in the control of larval stages of insect pest, *Trichoderma spp* used in the control of soil pathogens

There are three practices that are used to introduce organisms into an environment under the biological control method;

- **Introduction**- The bioagent is introduced into a locality for its establishment against its host
- **Augmentation**- the population of the already present natural enemies in the environment is enhanced by releasing laboratory reared or field collected agents in numbers that would suppress the pest or disease
- **Conservation**- the natural enemies within the environment are protected from being killed through practices like not spraying broad spectrum chemicals that could reduce their populations

Chemical Methods. In IPM use of chemicals is considered as the last resort when all other methods of pest management have failed to jeep the pest populations below economic threshold levels.Use of pesticides should be need based, judicious, based on pest surveillance to minimise not only the cost involved, but also to reduce associated problems. While going for chemical control, we must understand thoroughly what to spray, when to spray, where to spray and how to spray, keeping in mind the following points:

2.3.4 SUB-MODULE 4: SAFE USE OF PESTICIDE

Introduction

Pesticides are hazardous and toxic to pests, humans and the environment. Therefore, Suitable and proper precautionary measures before, during and after pesticides use will guarantee safety of the ecosystem. Pesticides will cause adverse effects if intentionally or accidentally ingested, when they come in contact with the skin or inhaled. Other risks include contamination of drinking-water, food, soil and burning and/or scorching of plants. Special precautions must therefore be taken during transport, storage and handling. Spray equipment should be regularly cleaned and maintained to prevent leakage and spillage of pesticides. In general, all personnel working with pesticides should have proper training on safe use and first aid skills.

Procedures

Creating awareness before control. Pest and pesticide management are very important factors for safe agricultural products for human consumption as well as maintaining the natural environment. pesticides used in the management of Desert Locusts in general is always of concern to the human health, wildlife and the environment, therefore, there is need for involvement of the surrounding communities in the control program through sensitization(community Baraza's & Meeting) and planning for the control operations. The approach will ensure total participation and compliance during Desert Locust control period while

safeguarding other non-targeted organisms and the environment. There is a need for joint efforts by the Ministry of Agriculture Livestock, Fisheries and Cooperation (MoALF&C) through the Plant Protection Services Division and other players in the management of Desert Locust.

Transportation and Storage Pesticides. PPSD will be in charge of procurement, storage and transportation of pesticides for the management of trans boundary and migratory pests like Desert Locusts. Pesticide movement from the central store to the regional areas of control to be done by PPSD under the prescribed rules. This will ensure NEMA compliance through minimising and/or eliminating exposure of hazardous chemicals to the environment and ecosystem during transportation and storage.

Control operations. For the control operation to be effective, efficient and adhere to the safety measures/standards to the environment, the following factors must be in place,

- Target pest
- The behaviour, biology and ecology of the pest will determine the type of chemical for use, the time, place and stage to institute the control and finally the threshold level to warrant the control.
- Selected Pesticide
- Toxicity level and effects to the environment, Targeted pest, efficiency and effectiveness of action, trade name, Registration number and manufacturer information.
- Control expertise and equipment
- Control and handling of pesticides to be done by qualified and trained personnel. Since desert locust information and management is controlled at the MoALF&C, all the control operation for trans boundary pests, therefore, to be coordinated by the PPSD.
- Post-spray assessment
- The aim of post-assessment is to check on the efficacy of the Pesticide and the Impact on the surrounding environment. The information obtained to be used in making conclusion, recommendation or advice the subsequent decisions and policies for the country.
- Method of disposal of unused Pesticide and pesticide containers
- In a well-planned spraying operation the amount of pesticide solution required for the job should have been worked out carefully so that there is little or no pesticide left over.

Pesticides are poisonous and it is bad for the environment and dangerous to people and other animals when exposed. This means that preparing too much spray is a waste of money and effort because the pesticide will not be effective if it is used later. Therefore, an adequate amount to be prepared for a single operation program.

Disposal of Unused Pesticide

If there is any pesticide left over at the end of a spraying operation then it is important that it be disposed of correctly. This means getting rid of the chemical so that it has no harmful effect on the environment, including people and their pets. If it is not possible to use up all the mixed pesticide, then the following steps should be taken to get rid of leftover pesticide safely. If further spraying is going to take place the next day then use any leftover pesticide on that job. However if no more spraying is planned then the following procedure will apply.

- Choose a place well away from community buildings and meeting/play areas, any streams, water supply areas, or low-lying areas where water may collect or there may be a high water table. Near the storage shed or at the soak pit may be appropriate.
- Dig a hole 50 cm deep.
- Cover the bottom of the pit with a 25 to 40 mm layer of hydrated lime.
- Pour the unwanted pesticide into the hole.
- Cover with soil.

Disposal of Empty Pesticide Containers

- The lids of all containers should be removed before disposal.

- Glass or plastic containers must be buried deep in an isolated area away from water supplies. If it is safe to do so, it is a good idea to break glass containers before disposal. Plastic containers must be punched with holes so that they cannot be used to carry water.
- Glass or plastic pesticide containers which cannot be broken or punched with holes must never be left around in case people use them for some other purpose.
- Metal containers should be made unusable by punching holes in the top and bottom and then crushing it. Flattened containers are easier to bury or dispose of at the pit. Drum crushers for pesticide containers should be located at different regions.
- Never burn pesticide containers because they may give off poisonous gases. Never use these containers or any Pesticide treated materials, such as wood on fire. A summary of the Standard Operating procedures (SOPs) for safe use of pesticide in the control of Desert locusts is provided
- Never burn pesticide containers because they may give off poisonous gases. Never use these containers for or any pesticide treated materials such as wood on fires.

Safety Measures for handling Pesticide/Chemical

Pesticide products can pose risk to humans, animals and the environment. Before choosing and purchasing a pesticide, it is important to read and understand the directions on the label. These information include:

- Brand or trade name
- Type of pesticide
- Active, inert ingredients and formulation
- Net content
- Registration Number
- Transportation and storage
- Mode of action
- Classification Number
- Date of manufacture and expiry
- Precautionary statement
- Do not carry pesticides in a vehicle used to transport food.
- Pesticides in drums must be put on a cushioned surface in the vehicle during loading and before transportation to avoid friction.
- Pesticides must not be filled to the brim in the packaging containers to avoid spillage and leakage.
- Pesticides should never be kept in a place where they might be mistaken for food or drink.
- Pesticides and pesticide containers should be kept in a separate building or room or in an enclosed area
- Pesticide stores must be dry, well ventilated and under key and lock mode not accessible to unauthorised people or children.
- If pesticides are in drums or carton boxes, they should be put on pallets or raised above the ground surface.
- The storage area must be used exclusively for pesticides and empty pesticide containers
- Outside storage area should have a strong fence, if the pesticide is stored in bulk.
- Spraying and Sprayer equipment
- Determine the method of spraying
- Choose the sprayer equipment for use
- Calibrate the sprayer equipment to determine the efficiency and effectiveness.

The operator should wear protective clothing before spraying. These include,

- Gloves: to protect the hands and wrist
- Boots: it should be worn above the ankle-height and Made of unlined light -weight rubber. They should be

washed inside and outside immediately after use or regularly.

- Overalls with wide trouser legs to be worn outside the boots to avoid drainage of pesticides into the boots.
- Goggles: to avoid chemical drifts to get into contact with the eye
- Head cover: for covering the head. Avoid head covers made from absorbent materials.
- Respirators with disposable cotton mesh to protect mouth and nose

During pesticide use:

- Use when necessary
- Use the right pesticide for the right pest at the recommended Mix (based on the label of manufacturer's manual).
- Wind direction and speed
- Do not spray in the opposite or against wind direction.
- Always spray when the weather is calm, preferably, in the morning hours or evening hours.
- Operator/Equipment spraying speed
- Remove only the amount of pesticides needed for one's day operation.
- Fill the spraying equipment to the required level and ensure there are no leakage and spillage.
- Move at a constant speed as determined by the calibration and the spraying pattern.
- Keep the pesticide to its original container.

After pesticide use

- Chemical and the containers
- Empty any insecticide remaining in the spray tank back into the original pesticide container.
- Careful disposal of empty containers and surplus pesticides. The containers should never be used or converted for feeding or water troughs since they are hazardous to humans, animals and the environment. Therefore the responsibility of pesticide users continues until all empty pesticide containers and surplus pesticides are disposed of safely and properly.
- SprayerCleaned, greasing movable parts and tightening the loose nuts

The operator

- Wash protective clothing immediately after use.
- Drying the PPE under the sun in the open.
- Checking the torn parts of the protective gears and repairing them.
- Proper Washing of the body specially, hand, face and legs with soap and clean running water.
- Safe and proper disposal of the empty containers and surplus pesticides.
- Safe custody of the spraying equipment and other materials.
- Store
- Properly cleaned in case of chemical spillage and leakage.
- Ensure the room is well ventilated
- The principle rule is, the pesticide store to be always under key and lock mode

Emergency Measures

Poisonings are usually acute that results from extensive skin contact or ingestion. Signs and symptoms vary with the type of pesticide and can sometimes be confused with those of other illnesses or abnormalities. Indications of pesticide poisoning include:

- General: Extreme weakness and fatigue.

- Skin: Irritation, burning sensation, excessive sweating, staining.
- Eyes: Itching, burning sensation, watering eyes, difficult or blurred vision, narrowed or widened pupils.
- Digestive system: Burning sensation in mouth and throat, excessive salivation, nausea, vomiting, abdominal pain, diarrhoea.
- Nervous system: Headaches, dizziness, confusion, restlessness, muscle twitching, staggering gait, slurred speech, fits unconsciousness.
- Respiratory system: Cough chest pain and tightness, difficulty with breathing and sneezing.

Pesticide poisoning should be reported as first as possible and the first aid measures be given immediately to the victim before seeking medical advice and help at the earliest time possible. If the patient is within the proximity of the medical facility, s/he should be rushed immediately or call the ambulance and the doctor immediately. Ensure the pesticide container or the sample is also availed to the doctor

First Aid Measures. It is the initial assistance given to a victim while medical help is on the way. The first step is to call an ambulance or a doctor while ensuring that the victim is breathing and is not further exposed to pesticides.

Pesticide on the Skin. Wash the skin immediately with soap and water. If no water is available, wipe the skin gently with a piece of cloth or paper to soak up the pesticide. Avoid rubbing or scrubbing. Remove contaminated clothing immediately and wash underlying skin. Clean pesticides from the skin. Remove the patient from the contaminated area

Pesticide in the eye. Wash the eyes thoroughly for about 10 minutes with clean water. Where eye irritation is severe, send the patient to a doctor.

Inhaled Pesticide. This may occur when working with pesticides as gaseous, vapour or dust in closed areas or atomized particles blown by wind. Remove patient from work and loosen clothing around throat and chest

Ingested Pesticide. People who have accidentally ingested pesticide must be treated by a doctor immediately. Meanwhile, keep the patient calm and comfortable and protect him from heat and cold.

If breathing has stopped:

- Give artificial respiration If no insecticide has been swallowed, mouth-to-mouth resuscitation may be given.
- Pull the patient's chin up and tilt the head back with one hand to keep the airway clear. Place the other hand on the patient's forehead, with the thumb and index finger toward the nose.
- Pinch together the patient's nostrils with the thumb and index finger to prevent air from escaping.
- Take a deep breath, and then form a tight seal with your mouth over and around the patient's mouth.
- Blow four quick, full breaths in first without allowing the lungs to deflate fully.
- Watch the patient's chest while inflating the lungs. If adequate respiration is taking place, the chest should rise and fall.
- Remove your mouth and allow the patient to breathe out.
- Take another deep breath, form a tight seal around the patient's mouth, and blow into the mouth again.
- Repeat this procedure 10–12 times a minute (once every five seconds)

General Care for the Patient. Make the patient lie down and rest because poisoning with organophosphorus and carbamate compounds is made worse by movement. Place the patient on her or his side with the head lower than the body. If the patient is unconscious, pull the chin forward and the head back to ensure a clear airway. Cover the patient with a blanket if he or she feels cold, and cool the patient by sponging with cold water if excessive sweating occurs. If the patient vomits spontaneously, ensure that he or she does not inhale the vomit. In the event of convulsions, put padded material between the teeth to avoid injury.

Further Reading

FAO. (2014). Food and Agriculture Organisation. Evaluation of field trials data on the efficacy and selectivity of

insecticides on locusts and grasshoppers. Report to FAO by the Pesticide Referee Group, 10th meeting. Gammarth, Tunisia.

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Methods for assessing livestock diseases – participatory methods for the rapid assessment of livestock diseases in pastoralist areas are listed in Table X; these methods have been used extensively.

2.4 MODULE 4

LIVESTOCK PRODUCTION AND MANAGEMENT

Realization of optimal production from livestock depends on careful balancing of husbandry practices. These include the choice of the species, creating enabling handling facilities and adapting appropriate routine management practices. In terms of productivity, the genetic potential contributes up to 30% of the output. The rest 70% depends on other attributes of which feeds, feeding management and health care are the most important under Kenyan livestock production systems. This module covers some important considerations for realization of optimal productivity from farm ruminants. It considers 11 submodules.

2.4.1 SUB-MODULE 1: LIVESTOCK BREEDS CHARACTERISTICS

Livestock Breeds and Breed Characteristics

There are five exotic dairy cattle breeds commonly reared. These were initially imported from Europe but overtime have been adapted to the local environment and through crossing contain some local blood of Zebu ecotypes. These are mainly used to produce milk under various production systems ranging from intensive zero grazing, semi-intensive and the extensive dairy production systems. The common breed types are Friesian, Ayrshire, Guernsey and Jersey which are mainly kept in the highlands of Kenya but through crossing and adaptation some of these breeds have been pushed to the semi-arid areas where they are used for milk production.

Kenyan Common Dairy Cattle Breeds

Friesian dairy cattle

Physical description: Coat colour predominantly black and white with a characteristic white triangular patch on the forehead and white socks from the knee joint to the hooves. (Table 2.17)

TABLE 2.17. FRIESIAN BREED CHARACTERISTIC

Physical description	Coat colour	Predominantly black and white There is a strain of brown and white called Red and white Friesian Characteristic white triangular patch on the forehead, Predominant white socks from the knee joint to the hooves on all four legs
	Coat hair	Short, fine and smooth
	Pigmentation	Black and pink
	Height at withers	Range from 1.5 -1.8 metres (m)
	Horns	Short horned Polled
	Shape of ears	Variable with prick ears of moderate size
Production	Milk	Lactation milk production of between 3,000kg to 8,000kgs Milk fats range 3.1 - 3.5% Milk protein range 3.3 - 3.6%
	Weight	Average mature live body weight range from 550-650kg. Higher bone: muscle ratio
	Fertility	75%
	Age at attaining mature weight	15 - 18 months
Reproduction	Age at first artificial insemination (A.I.) service	15 – 18 months
	Age at first calving	24 – 32 months
	Calving interval	15 – 24 months
	Number of parities	6 - 12

Friesian Cattle

Ayrshire dairy cattle

Physical description: Coat colour brown and white patches in almost equal amounts with some cows tending to dark mahogany colour (Table 2.18).

TABLE 2.18. AYRSHIRE DAIRY BREED CHARACTERISTICS

Physical description	Coat colour	Brown and white patches in almost equal amounts with some cows tending to dark mahogany colour
	Coat hair	Shinny Short and fine
	Pigmentation	Black to pink
	Height at withers	1.4 – 1.6m
	Horns	Mostly short-horned Few Polled
	Shape of ears	Horizontal or semi-pendulous
	Face	Straight
Production	Milk	In 305 days milk yield (MY) is from 3,000 – 6,000kg Daily MY 8 – 15kgs Fat from 3.8 - 4.5% Protein from 3.8 – 4.3%
	Weight and height	Mature live weight of 380 – 520kg with good finishing upon retiring from lactation Strong loins, long stooping from hip to pin bones Good spring of ribs and deep body capacity
Reproduction	Fertility	Above 85%
	Age at attaining mature weight	15 – 20 months
	Age at first A.I. service	15 – 24 months
	Age at first calving	24 – 30 months
	Calving interval	12- 20 months
	Number of parities	6 – 12

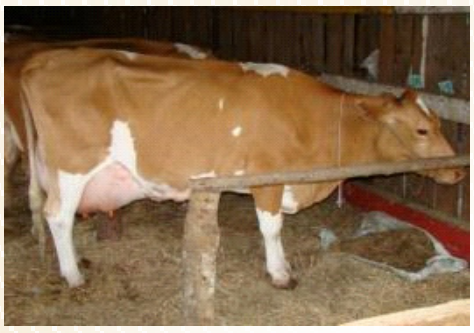
Mature Kenyan Ayrshire cows at an exhibition

Guernsey dairy breed

Physical description: Coat color Fawn brown to yellow to reddish-brown with white patches (Table 2.19).

TABLE 2.19. GUERNSY DAIRY BREED CHARACTERISTICS

Physical description	Coat colour	Fawn brown to yellow to reddish-brown with white patches
	Coat hair	Shinny short and fine
	Pigmentation	Pink
	Height at withers	1.3 – 1.5m
	Horns	Mostly short-horned Few Polled
	Shape of ears	Horizontal or semi-pendulous
	Face	Concave
Production	Milk	305 MY from 2,000-5,000kg Daily MY 10-18kgs Fat from 4.2-4.6% Protein from 3.8-4.3%
	Weight and height	Mature live weight of 320 – 500kg and 500-700kgs females and males respectively Weaning weight: 50-100kgs
Reproduction	Fertility	Above 80%
	Age at attaining mature weight	14 – 18 months
	Age at first A.I service	13 – 18 months
	Age at first calving	22 – 27 months
	Calving interval	12- 18 months
	Number of parities	5 – 10



Mature Guernsey cow

Jersey dairy cattle

Table 2.20 presents the characteristics of Jersey dairy cattle

TABLE 2.20. JERSEY DAIRY BREED CHARACTERISTICS

Physical description	Coat colour	Kenyan Jersey are typically light brown in colour, though this can range from being almost grey to dull black
	Coat hair	Shinny short and fine
	Pigmentation	Black nose and almost white muzzle
	Height at withers	1.3 – 1.5m
	Horns	Mostly short-horned
	Shape of ears	Horizontal and straight
	Face	Concave with protruding eyes
Production	Milk	305 MY from 2,000 – 4,000kg Daily MY 10 – 15kgs Fat from 5.0 - 6.5% Protein from 3.8 – 4.5%
	Weight and height	Mature live weight of 250 – 350kg and 350 - 400kgs females and males respectively Weaning weight: 50 – 90kgs
	Fertility	Above 85%
Reproduction	Age at attaining mature weight	14 – 18 months
	Age at first A.I service	12 – 18 months
	Age at first calving	21 – 27 months
	Calving interval	12- 18 months
	Number of parities	10 -15

Mature Kenyan Jersey cow

Beef cattle breeds

There are several beef breed types comprising of crosses of local beef ecotypes with the exotics and there are locally adapted cattle produced from the pastoral production system. Most of the crosses are eventually finished through feedloting while some locally improved breed types are produced from the ranching production system. Surplus dairy male cattle also end up in the beef value chain. Some of the indigenous crosses of Boran, Sahiwal, East African Zebu have been crossed with Friesian, Angus, Ayrshire and Charolaise to produce terminal beef crosses for finishing in the feedlot. The Boran comprises of the improved Boran, Orma Boran and the North Frontier District (NFD) Boran which is native to northern Kenya and Southern Ethiopia and from which the improved Kenya Boran that was developed and is a prime beef breed for the region. The Sahiwal which originally came from Pakistan has been

adapted as a dual purpose animal that produces substantive amount of milk during the dry season and also produces good quality meat. The key improved beef breeds improved are presented in Table 2.21-2.26.

Kenya Boran

TABLE 2.21. KENYA BORAN BREED CHARACTERISTICS

Physical description	Conformation	The Boran is medium in size with a short head, loose dewlap, short strong legs and a large hump above the shoulders.
	Coat colour	Kenya Boran cattle are predominantly white, grey and various shades of brown. However other ranges of colour are acceptable except brindle and solid black.
	Coat hair	Fine short hair with loose and pliable skin which also has many sweat glands per unit area
	Pigmentation	dark pigmented
	Height at withers	They vary in height from 114 - 147cm tall
	Horns	They can be horned or polled
	Size of ears	Small ears
Production	Average daily gain yearlings (kg/ day)	0.8kg
	Average Weaning weight (kg)	240kg
	Mature weight of female (kg)	Female being notably small weighing about 380 - 450kg
	Mature weight of bulls (kg)	Male grows to a large size weighing approximately 500 - 850kg
	Carcass quality	Consistent good quality of meat better than other Zebu breeds for meat tenderness, carcass marbling and rib eye area.
Reproduction	Average age at puberty	13 months
	Calving rate (%)	90%
	Calving Ease	High
	Age at first calving (months)	27 months
	Calf survival rate (% per year)	??
	Calving interval (months)	14 months
	Consumable meat (%)	??

Boran cattle

Kenyan Sahiwal

Table 2.22 presents the characteristics of the Kenyan Sahiwal.

TABLE 2.22. KENYAN SAHIWA BREED CHARACTERISTICS

	Variable	Expression/ value
Physical description	Conformation	The Sahiwals are heavily built with straight and long face, the brow slopes back to the poll and the line from brow to muzzle is straight and long. The hump is in the cervico-thoracic position.
	Coat colour	Reddish brown to chestnut
	Coat hair	Short, straight and smooth
	Skin pigmentation	Pigmented, moderately thick, loose and pliable
	Height at withers, cm	132-148cm and 124-138cm for male and female respectively
	Horns	Horns
	Shape of ears	long drooping ears and set behind and level with the eyes.
Production	Average daily gain yearlings (g/day)	490
	Weaning weight (kg)	160-180
	Body weight at 12 months of age (kg)	205
	Average Mature weight of females (kg)	425
	Average Mature weight of bulls (kg)	500
	Carcass quality	Lean meat with even good marbling
Reproduction	Average age at puberty	30 months
	Calving rate (%)	93
	Calving Ease	High
	Age at first calving (months)	39
	Calf survival rate (% per year)	96
	Calving interval (months)	441 days
	Fertility (%)	89
	Average milk daily yield (Kg)	1574kg in 293 days
	Butter fat %	3.5-5.3
	Consumable meat (%)	??

Kenyan Sahiwal breed

Indigenous cattle breeds (Small East African Zebu)

Indigenous cattle population in Kenya is dominated by short-horned zebu types with thoracic hump. These cattle are

distributed throughout the country and have developed adaptive features and characteristics through selection under varied environmental conditions. The Small East African Zebu (SEAZ) which are believed to have originated from Asia, are further categorized in various groups mainly based on communities that keep them as well as the geographical location and or production environments in which they are found. They are mostly found in pastoral communities within low input production systems and are of varied coloration and morphology due to the broad environmental adaptation. Among some of the common examples are the Maasai, Kamba, Kikuyu, Taita, Nandi, Turukana, Teso, Kavirondo and Jidu Zebu amongst others. However, it is important to note that most of these traditional ecotypes have become extinct due to extensive cross breeding with exotics and only traces of their crosses are commonly found. Common breed characteristics are as represented below.

Maasai Zebu

Maasai Zebu is predominantly found in southern Kenya extending to north-east Tanzania with close association with the Maasai community. Comparatively, it is the largest of all SEAZ types. It is mainly kept for milk and only slaughtered during special social ceremonies. Table 2,23 presents the characteristics of this zebu.

TABLE 2.23. MAASAI ZEBU BREED CHARACTERISTICS

Physical description	Coat colour	The type exhibits varied coat colour and conformation but black and white patterns are predominantly evident
	Coat hair	Short, fine, shiny and smooth
	Pigmentation	Black
	Height at withers (cm)	Females: 110 – 135 Males: 118 – 140
	Horns	Short horned while some are polled
	Ear orientation	Lateral
Production	Milk (kg/day)	1 - 2
	Mature live body Weight (kg)	Females: 275 – 385 Males: 300 – 445
Reproduction	Fertility	Above 87%
	Age (months) at attaining mature weight	24 - 36
	Age at first service (months)	30 - 36
	Age at first calving (months)	36 - 45

Kamasia/Samburu Zebu

Kamasia Zebu is predominantly found in central Kenya plains within Samburu County. It has long been kept by the Samburu community. Few populations are also found in Laikipia and Baringo Counties. It has a cervical-thoracic hump. Tolerant to tick-borne diseases, drought and can walk long distances in search of water and pasture. Mainly kept for milk and meat. Thable 2.24 presents the characteristics of this cattle.

Table 2.24. Kamasia/Samburu Zebu breed characteristics

Physical description	Coat colour	Varied with red/brown being predominant in most of the herds with spotted patterns
	Coat hair	Short, fine, shiny and smooth
	Pigmentation	Black and/or brown
	Horns	Short horned while some are polled
	Ear orientation	Drooping

Table 2.24. Kamasia/Samburu Zebu breed characteristics		
Production	Milk (kg/day)	1-1.5
	Mature live body weight (kg)	Females: 120 - 200 Males: 150 - 250
	Fertility	Above 80%
Reproduction	Age at attaining mature weight (months)	24 - 36
	Age at first service (months)	36 - 48
	Age at first calving (months)	30 -36

Winam or Kavirondo Zebu

Winam Zebu is mainly found in western Kenya in the lowlands of the Lake Victoria basin, kept by the Luo and Luhya communities. It is comparatively the smallest of all SEAZ with varied horn shapes, sizes and orientation (Table 2.25). There is a notable variance in hump size and position. It is tolerant to tick-borne diseases and helminthes and kept mainly for draft (tillage), milk and cultural use e.g. in ceremonies.

TABLE 2.25. WINAM OR KAVIRONDO ZEBU BREED CHARACTERISTICS		
Physical description	Coat colour	Predominant black and white colour
	Coat hair	Short, fine, shiny and smooth
	Pigmentation	Black or brown
	Height at withers (cm)	Females: 94 - 125 Males: 195 – 365
	Horns	Short horned while some are polled
	Ear orientation	Lateral and medium size
Production	Milk (kg/day)	2 - 3
	Mature live body Weight (kg)	Females: 215 - 419 Males: 200 - 365
	Fertility	Varied for different reasons
Reproduction	Age at attaining mature weight (months)	18 - 24
	Age at first service (months)	24 - 30
	Age at first calving (months)	32 - 40

Nandi Zebu

Nandi zebu is predominantly found in north rift region, with the Nandi community. The breed is endangered due breed replacement, upgrading and crossbreeding. It is small in size and fine-boned. It has a thoracic hump varying in size and shape with round front and back. The hump is prominent in bulls and hangs backwards. The Nandi Zebu is the dairy type of the SEAZ, comparatively producing more milk than other zebu types. It has moderately developed udders with small closely placed teats.

TABLE 2.26. NANDI ZEBU BREED CHARACTERISTICS

Physical description	Coat colour	Variable, but many animals are plain black, red, brown or grey
	Coat hair	Short, fine, shiny and smooth
	Pigmentation	Black
	Height at withers (cm)	Females (Av): 152.7 Males (Av): 162.3
	Horns	Short horned Some polled
	Ear orientation	lateral and medium sized
Production	Milk (kg/day)	2 – 3
	Mature live body Weight (kg)	Females: 200 – 320 Males: 215 – 420
Reproduction	Fertility	???
	Age at attaining mature weight (months)	18 – 24
	Age at first service (months)	24 – 30
	Age at first calving (months)	32 – 40

GOAT BREEDS

Small East African Goat

Small East African goat (SEAG) is a diverse group of goats (Tables 2.27-2.32) with variable type, conformation and size of body. It is distributed throughout a wide and diverse range of environments in Kenya, Tanzania, Uganda and southwards through central Africa as far as Zaire, Angola and the north of Namibia. It is adapted to ASALs. The SEAG is known by different local names e.g. East African Dwarf, Sebei, Karamoja, Tanzania, and Zambian types. The breed group belongs to the group of short-eared and small-horned goats. They are hardy animals generally used for meat rather than milk. Table 2,27 presents the general characteristics of SEAG.

Small East African Goat

TABLE 2.27. SMALL EAST AFRICAN GOAT BREED CHARACTERISTICS

	Variable	Expression/ value
Physical description	Coat colour	Variable in colour type and pattern, ranging from pure white to black
	Coat hair	Short, fine and smooth
	Skin pigmentation	Black
	Height at withers, cm	60
	Horns	Horned Polled
	Shape of ears	Variable with prick ears of moderate size
Production	Average daily gain yearlings (g/day)	67
	Weaning weight (kg)	8.7
	Body weight at 12 months of age (kg)	15.8
	Mature weight of does (kg)	32
	Mature weight of bucks (kg)	36
	Average milk daily yield (g/day)	500
Reproduction	Age of doe at first kidding (months)	20
	Doe survival rate (% per year)	88.5
	Post-weaning survival rate (%)	89
	Fertility (%) (number of parturitions per annum)	89
	Twining rate	High
	Kidding interval (months)	9
	Consumable meat (%)(Consumable meat output as a percentage of live weight at slaughter)	65

Galla goat

The Galla goat originated from Arabia and it is widely distributed in ASAL's of Kenya, Ethiopia, Djibout, Eritrea and Somalia. It is mostly reared by Somali, Borana, Rendille, Gabra, and Oromia communities under extensive and semi-intensive pastoral to agro-pastoral, production system. This goat inhibits wide and diverse range of environments. Galla goat is utilized by these communities for milk, meat, skin, manure, socio-cultural/ collateral uses. In the regions where it is reared it is also known by other names such as Larger-White-Somali, Digodi, Marebo, Boran Somali, Benadir and Gigwain. The breed has two sub-types known as Degyir and Degeun. Degyir. Degeun are coloured around the head and lower legs with a black stripe along the spine. This is a meat goat but there are some milk variants that produce milk under pastoral production systems. Table 2.28 summarises the characteristics of this type of goats.

Galla goat

TABLE 2.28. GALLA GOAT BREED CHARACTERISTICS

Galla Goat	Variable	Expression/ value
Physical description	Coat colour	Predominantly white
	Coat hair	Short, fine and smooth
	Skin pigmentation	Black
	Height at withers	Buck 70-75 cm Doe 60 cm
	Horns	Horned Polled
	Shape of ears	Horizontal or semi-pendulous
	Face	Straight
Production	Birth weight (kg)	3.0 – 3.5
	Weaning weight (kg)	18.0 – 24.0
	Body weight at 12 months of age (kg)	28.0 – 32.0
	Mature weight of does (kg)	45-55
	Mature weight of bucks (kg)	70
	Average milk daily yield (g/day)	1 Litres
Reproduction	Age of doe at first kidding (months)	20
	Doe survival rate (% per year)	??
	Post-weaning survival rate (%)	99
	Fertility (%) (number of parturitions per annum)	75
	Twining rate	Low
	Kidding interval (months)	9
	Consumable meat (%)(Consumable meat output as a percentage of live weight at slaughter)	54 - 60

Boer goat

This is a medium sized breed for meat. It is characterized by white body and red head and neck. White patches can be found on the forehead, face and ridge of the nose. Completely white or red Boer are not un-common. It is a native of South Africa and the name Boer means farmer in Afrikaan. Boer goats have large drooping ears and the muzzle resembles that one of sheep. Its fast growth rate, high meat proportion to body weight, high fertility and adaptability to diverse environments makes them popular and it is widespread to other countries apart from South Africa including; Namibia, Botswana, Zimbabwe, Kenya, India and America. It is reared in semi-intensive and extensive livestock systems. Table 2.29 presents the characteristics of this type of goat.

Boer goat

TABLE 2.29. BOER GOAT BREED CHARACTERISTICS

	Variable	Expression/value	
Physical description	Coat color	White bodies with distinct brown heads. Completely white or brown are also found. In some instances, white with brown spots or brown with white spots do occur.	
	Coat hair	Short and smooth hair	
	Skin pigmentation	Brown	
	Height at withers: Buck		
	Doe		
	Shape of ears	Long and pendulous	
	Horns	Both sex horned	
Production	Birth weight		
	Weaning weight	30-35	
	Body weight at 12 months	45-70	
	Weight of mature does	86-104	
	Weight of mature buck	91-154	
	Milk yield per day		
	% consumable meat relative to live weight	51	
Reproduction	Age of doe at first kidding		10-12 months
	Fertility		High
	Twining		High

Alpine goat

Alpine is a medium sized dairy goat. It originated from France and spread to the rest of the world. It is a popular dairy goat in Kenya due to its high milk production and adaptability to different climatic conditions. The breed is reared under intensive and sem-i intensive production system.

The breed was introduced in Kenya from Germany in the early 1980s in the following counties: Nyeri, Murang'a, Kirinyaga, Embu and Kiambu. In Nakuru County, they are reared by farmers under the umbrella of Nakuru Sheep and Goats Breeders Association. After several years of breeding, a Kenya Alpine has been registered. Table 2.30 presents its key features.

TABLE 2.30. ALPINE GOAT BREED CHARACTERISTICS

	Variable	**Expression/value**
Physical description	Coat color	Mainly gray, brown or black
	Coat hair	Short, fine and smooth with pronounced mane at the back
	Skin pigment	Black
	Height at withers: buck	80-90
	Height at withers: ewes	70-76
	Horns	Horned or polled
	Shape of ears	Erect and medium

TABLE 2.30. ALPINE GOAT BREED CHARACTERISTICS		
Production	Birth weight kg	2.0 – 3.5
	Weaning weight	15.0 – 18.0
	Body weight at 12 months	28.0 - 32.0
	Weight of mature does	50-60kg
	Weight of mature buck	70-76
	Milk yield per day	2.5- 4 litres
Reproduction	Age of doe at first kidding	18 – 24 months

Saanen goat

Saanen is a large dairy goat which originated from Germany and is spread in many countries. It is mainly found in highlands under intensive and semi intensive systems. The breed has been extensively crossbred with other dairy goats due its high milk production. The breed is prone to photo sensitivity and therefore it is not wide spread in the country. Table 2.31 summarises its key characteristics.

Saanen goat

TABLE 2.31. SAANEN GOAT BREED CHARACTERISTICS		
	Variable	**Expression/value**
Physical description	Coat colour	White or cream
	Coat hair	Short, fine and smooth
	Skin pigment	Pink
	Height at withers buck (cm)	81-92
	Doe	74-80
	Shape of ears	Erect and point upwards
	Horns	Horned or polled
Production	Birth weight Weaning weight Body weight at 12 months	
	Weight of mature does	50-70kg
	Weight of mature buck	70-100 kg
	Milk yield per day	3-5 ltrs
Reproduction	Age of doe at first kidding	20 months

Toggenburg goat

The breed originated from Switzerland and spread to the rest of the world. It's suited to Kenya highlands where heat stress is not a problem and fodder is of good quality. The breed is reared under both intensive and semi intensive systems. Toggenburg goats have proved to be well adapted and large flocks are found in agro-pastoral areas of Kenya. Toggenburg goats are reared in large numbers in the following counties where it is currently promoted by breed associations after it was introduced by Farm-Africa in 1996; Meru (Meru Dairy Goat Breeders Association), Tharaka-Nithi (Tharaka Nithi Dairy Goat Breeders Association), Kitui (Kitui Mwingi Dairy Goats Breeders Association) and Makueni (Utheu wa Aka Women SHG, Kibwezi). In Nakuru County Toggenburg goats are also reared in some good numbers by farmers who formed Nakuru Sheep and Goats Breeders Association. Table 2.32 summarises the key attributes of this type of goat.

Toggenburg Goat breed characteristics

TABLE 2.32. TOGGENBURG GOAT BREED CHARACTERISTICS

	Variable	Expression/value
Physical description	Coat color	Brown or grayish brown with distinct white stripes on the face and legs
	Coat hair	Short, fine and smooth
	Skin pigmentation	Brown
	Height (in cm) at withers buck	81-92
	Doe	74-80
	Shape of ears	Erect
	Horns	Horned or polled
Production	Birth weight	2.2 – 2.5
	Weaning weight	15 - 18
	Body weight at 12 months	24 - 26
	Weight of mature does	70kg
	Weight of mature buck	50kg
	Milk yield per day	1-3ltrs
Reproduction	Age of doe at first kidding	20 months

INDIGENOUS SHEEP BREEDS

Somali sheep

The Somali sheep is a hairy sheep native to Somalia. The Somali sheep is the direct forebear of the Blackhead Persian. It is white with a black head. It belongs to the fat-tail type, and both of the breed's sexes are polled. They are mainly reared for meat, are fat ramped and mainly found in Somali, North Eastern Kenya and Sudan. They are hardy;

the skin quality is higher than other indigenous hair sheep and is important for mutton production. This breed thrives well under harsh environmental conditions and has high potential for meat production. The breed characteristics are given in Table 2.33.

Black Headed Somali

TABLE 2.33. BLACK HEADED SOMALI BREED CHARACTERISTICS

	Variable	Expression/value
Physical description	Coat color	White body and black head dominant can be patchy, pied or plain
	Coat hair/wool	Short smooth hair
	Skin pigmentation	Black
	Height at withers	Ram 61.3 cm Ewe 59.9 cm
	Shape of ears	Medium and drooping
	Horns	Polled
Production	Birth weight	1.5 – 1.8
	Weaning weight	10 - 12
	Body weight at 12 months	Ram Ewe
	Weight of mature ram	29.5 kg
	Weight of mature ewe	25.8 kg
	Consumable meat (%)(Consumable meat output as a percentage of live weight at slaughter	35 - 40
Reproduction	Age of ewe at first lambing	20 – 28 kg
	Age at puberty	Male 9- 18 months Females 15 – 21 months
	Lambing interval	8 -11 years
	Reproductive live span	7 – 11 years
	Life time lamb	Upto 10 lambs

Black head Persian

The Blackhead Persian sheep has its origins in the Blackheaded Somali. The breed was developed in South Africa and was a cross between the Somali sheep and the South African Boer sheep for the drier areas of South Africa but

has spread to other parts of southern Africa and farther north, notably to Tanzania, Kenya, Ethiopia and even to Ghana. It has also been introduced for crossbreeding purposes to the West Indies, and to Central and South America.

This breed is popular in the arid and semi-arid areas due to its hardiness and resilience. It is used for meat and fat (for cooking). It is mostly reared under extensive system by pastoral communities in the marginal areas of the country. Table 2.34 presents the key characteristics of this sheep.

TABLE 2.34. BLACK HEAD PERSIAN BREED CHARACTERISTICS

	Variable	Expression/value
Physical description	Coat color	White body and black head and neck
	Coat hair/wool	Short smooth kemp
	Skin pigmentation	Black
	Height at withers	Ram Ewe
	Shape of ears	Long and pendulous
	Horns	Polled
Production	Birth weight	2.4 – 2.7 kg
	Weaning weight	12.5 kg
	Body weight at 12 months	Ram 32 kg Ewe 28.1 kg
	Weight of mature ram	68 – 70 kg
	Weight of mature ewe	50 - 52 kg
	Lactation period	84 days (Av. Yield 50 kg milk, 5.9 % fat)
	Consumable meat (%)(Consumable meat output as a percentage of live weight at slaughter	45 - 48
Reproduction	Age of ewe at first lambing	18 – 24 months
	Age at puberty	Male Females
	Lambing interval	6 – 15 months
	Lambing %	60- 90
	Fertility rate %	70.6
	Fecundity % (Lambs born/Ewe present p.a)	61
	Reproductive live span	
	Life time lamb	3.16
	Twining rate %	6.3

Merino sheep

The Merino sheep is a native of Spain but it originated from sheep of Asia Minor through North Africa and has since spread to many parts of Africa including Kenya and is suited to medium and high altitudes under ranching and agro-pastoral management systems. The breed is adapted to high rainfall grassland regions and is reported to be less susceptible to fly strike because of their smooth body in comparison to sheep with skin folds.

It is found in the highlands under intensive and semi intensive condition. It is hardy and has excellent mothering ability. It is a medium breed kept for meat and wool. Table 2.35 presents its key characteristics.

Merino

TABLE 2.35 MERINO BREED CHARACTERISTICS

	Variable	Expression/value
Physical description	Coat color	White
	Coat hair/wool	Fine wool
	Skin pigmentation	Pale
	Height at withers	Ram 73 -81 cm Ewe 67 – 70 cm
	Shape of ears	Medium and erect
	Horns	Horned or polled
	Birth weight	3.6 – 4.8 kg
	Weaning weight	28 – 30 kg
	Body weight at 12 months	Ram Ewe
	Weight of mature ram	80-105
	Weight of mature ewe	55-80
Production	Consumable meat (%)(Consumable meat output as a percentage of live weight at slaughter	36.8 – 38.5
	Wool weight (Ave)	3.9 – 4.5 kg
	Wool diameter	21 – 22 microns
	Wool (staple) length	8.9 – 9. 1 cm
	Wool texture	Fine

TABLE 2.35 MERINO BREED CHARACTERISTICS		
Reproduction	Age of ewe at first lambing	
	Lambing %	
	Fertility %	82 – 90.7
	Fecundity %	121.6
	Lamb survival %	81.2 - 88

Red Maasai

The Red Maasai is an East African fat-tailed sheep characterized by short reddish brown to almost black course hair. They are sheep of the semi-arid regions of Kenya and Tanzania, especially in Kajiado, Narok, Laikipia, Samburu and West Pokot Counties of Kenya and in Tanzania in Longido and Ngorogoro Districts in Arusha Region. Table 2.36 summarises its key characteristics.

Red Maasai

TABLE 2.36. RED MAASAI BREED CHARACTERISTICS		
	Variable	**Expression/value**
Physical description	Coat color	Red or black sometimes with white markings
	Coat hair/wool	Mottled or greasy hair
	Skin pigmentation	
	Height at withers	Ram 72 - 80cm Ewe 58 - 66cm
	Shape of ears	Long often drooping at an angle
	Horns	Male has twisted horns, females often lack horns
Production	Birth weight	2-3kg
	Lambing Interval	340 days
	Lambing rate %	80 – 84
	Weaning weight	15-20kg
	Av. DWG	128gm
	Body weight at 12 months	Ram 35-40 Ewe 25-30
	Weight of mature ram	58-80kg
	Weight of mature ewe	45-70kg
	Consumable meat (%)(Consumable meat output as a percentage of live weight at slaughter	??
	Milk yield per day	300ml
Reproduction	Age of ewe at first lambing	15 – 18 months
	Weaning rate	97%

Dorper

The Dorper sheep is a composite breed of South Africa developed at Grootfontein in 1940-50 with good mutton qualities. It was developed through the crossing of the Blackhead Persian ewes with the Dorset Horn rams. The Dorper sheep thrive in arid to semi-tropical climate and are suitable for areas with rainfall of only 100 to 760 mm. The breed has been exported to many countries throughout the world including Namibia, Zimbabwe, Zambia, Kenya, Mauritius, Malawi, Burundi, Israel, Saudi Arabia, and Australia. Table 2.37 summarises the key characteristics of this nd of sheep.

Dorper

TABLE 2.37. DORPER BREED CHARACTERISTICS

	Variable	Expression/value
Physical description	Coat color	White body and black head
	Coat hair/wool	Kemp with short coarse wool
	Skin pigmentation	Black
	Height at withers	Ram Ewe
	Shape of ears	Medium erect ears
	Horns	Male polled or with short horns, females polled
	Birth weight	3 – 4 kg
	Lambing Interval	8 months
	Lambing rate %	150 - 180
	Lamb survival %	90 - 96
Production	Fertility rate %	78 - 90
	Twining rate %	10
	Weaning weight	23 – 35 kg
	Av. DWG	243gm
	Body weight at 12 months	Male 40 - 50 Female 35 - 45
	Weight of mature ram	65 - 80
	Weight of mature ewe	55 - 65
	Consumable meat (%)(Consumable meat output as a percentage of live weight at slaughter	50 - 54
	Milk yield per day	
	Butter fat	5.5
Reproduction	Age of ewe at first lambing	12 – 15 months
	Weaning rate %	99 - 140

CAMELS

There are two main types of camels namely, the Bactrian camel (2 humps) and the dromedary (one-humped) mainly found in the cold deserts of China and Mongolia, and hot deserts of Africa and the Middle East respectively. They are mainly used for food by providing milk and meat and transport as a beast of burden. Camels can live for 40 years, but the productive lifespan is between 20 and 30 years. Different camel breeds are traditionally named after the ethnic communities who own and keep them. These are Somali, Rendille/Gabbra and Turkana breeds. Originally, they inhabited Garissa, Mandera, Wajir, Moyale, Marsabit, Turkana and Tana River counties. There is a third breed of camel called Pakistani which was imported from Pakistan into Laikipia ranches early 1990s. However, there is no pure Pakistan camels but exist crosses with Somali or Turkana breeds. Currently, Kenya has 6% of Africa's camel population with camel density in most ASALs estimated at 3.1 camels per km2. Camel is the key contributor to food and nutritional security through milk and meat to human populations in ASALs. In addition, it contributes to sustainable socio-economic wellbeing through sales of live animals and its products, payment of dowries and acting as economic security. Among the pastoral community, it's an indicator of wealth, prestige and honor

Somali camel

This is the breed with the highest camel population mainly inhabiting Garissa, Mandera, Wajir, Moyale, Isiolo and Tana River counties. It's mainly kept by the Somali community in the north eastern region of Kenya. It's also called Hoor, Sifta, Gelab and Aidimo depending on specific features of differentiation. Due to its comparatively better performance, it has been distributed to most ASAL environments in the county. Somali camel is known for high adaptability in hot and dry environments with a strong ability to walk for longer distances and going for a longer period without water in free range system of production. Its milk and meat are highly medicinal. Special products from camel include the nyir nyir (meat) and camel fat. Somali camel is the largest native single-humped breed. This and other camel breed characteristics are given in Tables (2.38-2.40). These Tables summarise the key characteristics of each camel types.

Somali camel

TABLE 2.38. SOMALI CAMEL BREED CHARACTERISTICS

Physical description	Coat colour	Creamy
	Coat hair	Short Males with dark brown hair line from withers to hump
	Average height at withers	2m
	Average abdominal girth	2.6m
	Average hump circumference	1.47m
Production	Meat	Average mature live weight from 450kg
	Milk	3-5 kgsper day Lactation length of 12-17 months
Reproduction	Age at first calving	4 to 5 years
	Average at calving interval	2.5 years

Rendille/Gabbra breed

This is the second largest native camel breed. It's named after the Gabbra and Rendille communities that inhibit the northern counties of Kenya, namely: Marsabit, Moyale and Samburu. The breed highly adapted to extreme rocky desert condition of Chelbi desert and can tolerate very severe drought than any other camel breed. The light coat colour makes able to thrive and withstand hot and dry environmental conditions.

Rendile/Gabbra camel

TABLE 2.39. RENDILE/GABBRA CAMEL BREED CHARACTERISTICS

Physical description	Coat colour	Light Creamy to whitish
	Coat hair	
	Average height at withers	1.8m
	Average abdominal girth	2.45m
	Average hump circumference	1.27m
Production	Meat	Average mature live weight from 300-550kg
	Milk	1-3 kg per day Lactation length from 12 to 17 months
Reproduction	Age at first calving	5 to 6 years
	Average at calving interval	3 years

Turkana breed

This is the smallest camel breed in Kenya. It is named after the Turkana community that keeps it. It is native to eastern parts of the country specifically in Turkana County but also inhabits parts of West Pokot, Baringo and Samburu Counties. The breed is highly adapted to rough terrain and extreme drought. In addition to milk and meat, the Turkana community utilizes blood tapped from live animals for food for the young and elderly.

Turkana breed

TABLE 2.40. TURKANA BREED CHARACTERISTICS		
Physical description	Coat colour	Dark brown hairs
	Coat hair	Long hairs along the backline and the hump
	Average height at withers	1.79 m
	Average abdominal girth	2.25 m
	Average hump circumference	1.21 m
Production	Meat	Average mature live weight from 250-500kg
	Milk	1 kg to 2.5kgs per day Lactation length from 12
Reproduction	Age at first calving	5 to 6 years
	Average at calving interval	3 years

INDIGENOUS CHICKEN

The indigenous chicken (IC) (Gallus domesticus) is found commonly within human settlement and comprises more than 80% of overall poultry populations in rural villages. They exhibit extensive phenotypic diversity due to varying environmental adaptation and low selection pressures. They have not been classified into breeds, but are ecotypes named according to their morphological features. The main types include; normal feathers, frizzled, naked neck, crested etc.

The IC plays a significant role in the economic and social life of resource- poor households, contributing to a cheap source of animal proteins and cash incomes. They are highly adapted to the harsh scavenging conditions limited and poor feed resources, disease and parasitic challenges

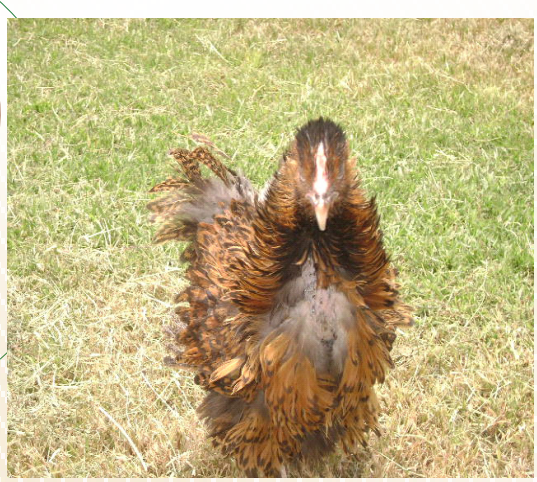
Normal feathers

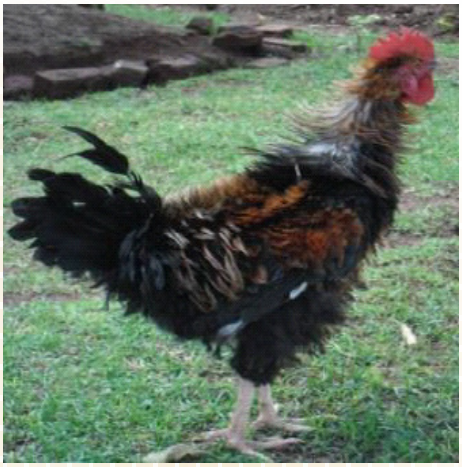
They are the most common type of birds reared by farmers, good for both egg and meat production. Widely distributed and are of various plumage colours and highly adapted to diverse environments

Female (left) and Male (right)

Frizzled feathers

It is a dual purpose breed with the main characteristic of curled or frizzled plumage. The plumage curves upwards and forward





Female (left) and Male (right)

Naked neck

This ecotype is devoid of feathers on its neck. It's a dual purpose bird; lays a reasonable number of eggs and are also considered desirable for meat production

Naked neck (left) and Crested (right)

Crested

The ecotype has a characteristic crested head. Table 2.41 presents the key characteristics of this type of IC.

TABLE 2.41.

	Variable	Expression/ value
Physical description	Plumage colour	Variable in colour type and pattern, ranging from red, brown, black ,white, gray orange to yellow
	Comb type	Single, pea, rose, cushion
	Wattle colour	Red, white, red/white, yellow, black, grey
	Earlobe colour	Red, white, red/white, brown, black, blue
	Iris colour	Yellow, orange, brown, red, pearl
	Skin colour	White, grey, yellow, black
	Shank colour	Gray, yellow, white, black, green, blue

TABLE 2.41.

Production	Average mature body weight Males (Kgs)	1-2
	Average mature body weight Females (Kgs)	2-3
	Average age of maturity (months)	6-8
	Average length of productive life (years)	3-4
	Average daily gain (gms)	8-10
	Average carcass weight (kgs)	1.5
	Dressing %	70
	Age at first egg (months)	6-7
	Clutch size	10-15
	Average eggs per year	40-60
	Average egg weights(gms)	35
Reproduction	Broodiness (times per year)	2-3
	Number of eggs set per hen	8-12
	Average litter size	7
	Chicks survival rate %	60

2.4.2 SUB-MODULE 2. PASTURE AND FODDER PRODUCTION

Cattle, sheep and goats are the most common ruminants kept in the farms, whose production all over the world are primarily based on forages, with tropical countries invariably leading in heavy reliance on forages and crop residues throughout the year. For instance, majority of dairy herds on smallholder farms, largely depend on natural tropical grass pastures and crop residues for nourishment. Kenya and indeed the whole of East African region is widely recognized as the home for many important forages, of which some important ones are described below.

Napier grass (*Pennisetum clandistenum*)

Napier grass

Strengths

- High dry matter yields.
- Very palatable, high quality forage .
- Drought tolerant.

Limitations:

- Needs high fertility.
- Matures rapidly, becoming stemmy.
- Usually needs to be planted vegetatively

Feeding value

- Extremely palatable to all classes of livestock when provided young and leafy
- Note: There is great variation in nutritional value depending on the stage of growth of the Napier grass. Young regrowth of about six (6) weeks can have crude protein of about 10%, falling to 7.6% at 10 weeks growth. With good supply of nitrogen, protein levels can rise to almost 20% and digestible energy levels can vary from 68-74% in the same growth period. Once Napier starts growing stems, palatability and nutritional value quickly decreases to become almost value less for livestock.
- Should not be a sole diet, i.e be fed in mixture with other supplementary feeds such protein forages and concentrates to sustain high production.
- Companion species
- Grasses: Not sown with other grasses.
- Legumes: Normally not planted with legumes, but will grow with vigorous twining legumes such as Desmodium spp. or with the shrub/tree legume , Leucaena leucocephala

Inter-cropping of Napier and desmodium for improving nutritive value (left), and Napier -Vetch and intercrop at KALRO-Naivasha (right) (Photo: T. Lanyasunya)

Naivasha star grass or Bermuda grass (*Cynodon dactylon*)

Naivasha star grass or Bermuda grass *(Cynodon dactylon*), and (right) Bermuda grass young re-growth mature for grazing (Photo: J. Ouda)

Grows in grassland, lawns and pastures and as a weed in cultivation. Locally dominant along roadsides and overgrazed and trampled areas.

Strengths

- Widely adapted to soils and climate.
- Palatable.
- High nutritive value when young.
- Excellent ground cover for soil conservation.
- Tolerant of heavy grazing.
- Makes useful hay .
- Tolerant of salinity.
- Tolerant of flooding.

Limitations

- Low production unless well fertilised.
- Can become a weed in cultivation.
- Difficult to eradicate.

Nutritive value

Crude protein varies with age of material and level of nitrogen fertilisation, from about 3 -9% in old grass, to about 20% in young, well-fertilised grass. Dry matter digestibility varies from 40 - 69% with genotype.

It is very palatable if kept short in growth and fertilized. Excellent grazing for village geese, ducks, goats, cattle and buffaloes if not trampled too much by these latter heavy beasts. The rhizomes are given to horses. Biomass productivity depends on the cultivar used, the time of year and the amount of nitrogen available. Dry matter (DM) yields of 1,000-3,000 kg/ha per month. 'Coastal' yields up to twice as much as most common ecotypes. Annual DM yields are generally of the order of 5-15 t/ha.

Elephant grass (*Panicum maximum*)

Elephant grass (Photo: J. Ouda)

Widely naturalised in the tropics. It grows naturally in open grasslands, usually under or near trees and shrubs, and along riverbanks.

Uses/applications

Long term pasture if fertility is maintained. Ideal for cut-and-carry, although bristly types may cause discomfort to forage collector. Suited to agroforestry due to shade tolerance. Reasonably palatable when mature, providing good roughage for use in conjunction with urea molasses licks. It has been used successfully for making silage and hay.

Production potential

Dry matter. Commonly (10-) 20-30 (-60) t/ha DM, depending on variety and growing conditions (particularly if high levels of N applied).

Animal production. Can achieve up to 0.8 kg/hd/day LWG and up to 1,200 kg/ha/yr LWG (commonly 300-500 kg/ha/yr LWG) depending primarily on stocking rate and N fertiliser rate.

Strengths

- Very leafy.
- High quality feed.
- High production potential.
- Readily eaten by all stock.
- Suited to grazing and cutting.
- Drought tolerant.
- Early season growth in some lines.

Limitations

- Requires fertile soils.
- Intolerant of waterlogging.
- Intolerant of heavy grazing.
- Becomes stemmy if not cut or grazed frequently.

Sorghum (*Sorghum bicolour*)

Sorghum at onset of flowering and at grain maturity stages in Narok (Photo: **J.** Ouda)

Uses/applications

The various types of hybrids have different agronomic features and uses.
Sweet sorghum hybrids tiller well, are tall with fine stems, flower early and have low prussic acid. They grow rapidly but some cultivars selected for later flowering are easier to manage as they remain leafy for longer.

Feeding value

Moderately palatable and digestible when young. The sweet sorghum hybrids keep a higher free sugar content in the stem and are more suitable as stand-over feed in dry season.

Toxicity

Leaves can be poisonous to grazing livestock due to hydrogen cyanide (prussic acid), especially in young dark-blue coloured regrowth after a dry spell.

Strengths

- Easy establishment and rapid growth.
- Very productive on fertile soils.
- Pioneer species with other perennial grasses or legumes.

Limitations

- Demands high soil fertility.
- Prussic acid poisoning.
- Seed cannot be distinguished from that of S. halepense.

African foxtail grass (*Cenchrus ciliaris*)

African foxtail grass

Widely naturalised in sub-humid and semi-arid tropics and subtropics.

Uses/applications

Mainly used as a permanent pasture, but can be used for hay or silage. Not suited to short-term pasture because too difficult to remove and binds nutrient.

Moisture

The most drought tolerant of the commonly sown grasses, Cenchrus ciliaris occurs naturally in areas with average annual rainfall from as low as 100 mm up to about 1,000 mm, but most commonly between 300 and 750 mm. Under cultivation, it has been grown in areas with rainfall as high as 2,900 mm, although this is exceptional. Does not survive prolonged waterlogging, particularly in cold season, but can stand up to five days of flooding with negligible adverse effect. Losses of 15-70% occur after 20 days of flooding. Tolerance of flooding varies with ecotype, the taller varieties appearing to be more flood-tolerant.

Defoliation

Slow to establish and grazing may need to be delayed 4-6 months after sowing, and up to 9-12 months, depending on establishment conditions. Very tolerant of regular cutting or grazing. Since quality declines rapidly with age, should be cut or grazed at least every eight weeks. Leafiness is maintained by low cutting at about 7 cm.

Fire

Very tolerant of, and favoured by fire. Cover of Cenchrus ciliaris can increase, and populations of associated fire-susceptible species decrease in a fire regime.

Compatibility (with other species)

Cenchrus ciliaris is a particularly aggressive grass, by virtue of its extensive root system competing with associated species for water and nutrients. It also appears to be allelopathic (suppression of other species by exudation of phytotoxic chemicals that inhibit germination and growth of other plants).

Feeding value

Protein values are mostly in the range of 6-16%, and digestibility from 50-60%, depending on age of growth, cultivar, and soil fertility (incl. fertiliser use). P levels are usually higher than in other tropical grasses and range from 0.15-0.65% in the DM. Yields depend greatly on soil fertility and growing conditions, but are mostly in the range of 2-9 t/ha DM, and under ideal conditions, up to 24 t/ha DM. It can carry up to 1 steer or 6 sheep/ha, depending on rainfall and soil fertility. Cattle can gain up to 180-200 kg/hd/yr at 2 ha/beast on fertile soils under good growing conditions.

Strengths

- Persistent.
- Very drought tolerant.
- Quick to respond after rain.
- Widely adapted.

Limitations

- Needs high fertility for production.
- Establishment is difficult on clay soils.
- Will not survive prolonged flooding or waterlogging.
- Can cause 'big head' in horses.
- "Fluffy" seed is difficult to sow.
- Threat to certain sub-humid to arid environments.

Leucaena

Leucaena at KALRO-Lanet (Photo: JO Ouda)

Uses/applications

It is highly valued as ruminant forage and as a fuelwood by subsistence and semi-commercial farmers throughout southeast Asia and parts of central Asia and Africa.

It can be planted in hedgerow systems with grass for cattle production. Can also be used as a shade tree over coffee and grown in dense rows as a living fence and used to support vine crops such as pepper and passion fruit. It is a highly researched species for alley farming systems.

Moisture

It prefers subhumid and humid climates of 650-1,500 mm and up to 3,000 mm annual rainfall and tolerates up to seven months dry season. It does not tolerate waterlogged soils or extended periods of flooding (>3 weeks).

Defoliation

It is extremely tolerant of regular defoliation by cutting or grazing once established.

Fire

Mature plants are tolerant of fire, re-growing readily from burnt stumps. Fire can be used to reduce height of grazed hedgerows, although productivity in the subsequent year may be poor.

Compatibility (with other species)

Compatible with a range of grass species. Can be difficult to establish leucaena into existing grass pastures without complete grass control or clean cultivation. In the dry tropics, can be difficult to establish a grass into mature leucaena due predominantly to competition for moisture. Grass establishment can be particularly problematic on strongly self-mulching clay soils.

Companion species

Grasses: Can be grown with buffel grass (*Cenchrus ciliaris*), Elephant grass (*Panicum maximum*). Rhodes grass (*Chloris gayana*) Normally grown as a hedgerow with grasses or crops grown between hedgerows. Can be grown as a sole species as a protein bank.

Feeding value

Leucaena leucocephala foliage is noted for its very high nutritive value for ruminant production. Typical values for the edible fraction are 55-70% digestibility, 3-4.5% N, 6% ether extract, 6-10% ash, 30-50% N-free extract, 0.8-1.9% Ca and 0.23-0.27% P. Na levels are generally below requirements for ruminants at 0.01-0.05%. Leaves also contain 2-6% condensed tannins (CT), phenolic compounds which bind and protect dietary protein from degradation in the rumen. Providing that the protein-CT complexes dissociate post-ruminally allowing N absorption in the lower gut, CTs have the potential to increase protein uptake.

Palatability/acceptability

It is highly palatable to most grazing animals, especially compared to other forage tree legumes such as Calliandra (*Calliandra calothyrsus*) and Gliricidia (*Gliricidia sepium*).

Toxicity

Contains mimosine, a non-protein amino acid that has antimitotic and depilatory effects on animals. Concentrations in young leaf can be as high as 12% and the edible fraction commonly contains 4-6% mimosine. Mimosine is acutely toxic to animals but is normally converted to 3-hydroxy-4(IH)-pyridone (DHP) upon ingestion. DHP is goitrogenic and, if not degraded, can result in low serum thyroxine levels, ulceration of the oesophagus and reticulo-rumen, excessive salivation, poor appetite and low liveweight gains, especially when the diet contains more than 30% leucaena. The anaerobic rumen bacteria, Synergistes jonesii, occur in most countries in the Americas and Southeast Asia and completely detoxify DHP and its breakdown products.

Production potential

Yields of forage vary with soil fertility, rainfall, altitude, density and cutting frequency from 1-15 t/ha/year. Leaf yield is maximised by cutting at 6-12 week intervals during the growing season. Yields in extensive hedgerow plantings in the dry tropics and subtropics generally range from 2-6 t/ha/year. Very high yields (>15 t/ha/year) in Southeast Asia and Hawaii, with plants 0.5-1.0 m apart in rows 1-3 m apart. Fuelwood yields compare favourably with the best tropical trees, with height increments of 3-5 m/year and wood increments of 20-60 m^3/ha/year for arboreal varieties.

Animal production

Excellent growth rates of 1.26 kg/head/day for cattle grazing leucaena-buffel grass (Cenchrus ciliaris) pastures over a 6-month period were reported in Queensland, Australia, although growth rates are more commonly 250-300 kg/head/year (0.7-0.85 kg/head/day). Under irrigation in northwestern Australia, annual liveweight gains of up to 1,700 kg/ha/year have been recorded for cattle grazing at 6 head/ha.

Feeding value

Nutritive value. It leucocephala foliage is noted for its very high nutritive value for ruminant production. Typical values for the edible fraction are 55-70% digestibility, 3-4.5% N, 6% ether extract, 6-10% ash, 30-50% N-free extract, 0.8-1.9% Ca and 0.23-0.27% P. Na levels are generally below requirements for ruminants at 0.01-0.05%.

Leaves also contain 2-6% condensed tannins (CT), phenolic compounds which bind and protect dietary protein from degradation in the rumen. Providing that the protein-CT complexes dissociate post-ruminally allowing N absorption in the lower gut, CTs have the potential to increase protein uptake.

Palatability/acceptability. It is highly palatable to most grazing animals, especially compared to other forage tree legumes such as *Calliandra calothyrsus* and *Gliricidia sepium*.

Strengths

- Very high nutritive quality for ruminant livestock.
- Highly productive on suitable soils.
- Tolerant of prolonged dry periods and retains leaf into dry.
- Produces multiple products in a wide range of farming systems.

Limitations

- Poorly adapted to acid infertile soils.
- Poor growth at low temperatures and is susceptible to frosting.
- Relatively weak in seedling stage and slow to establish.
- Mimosine and condensed tannins limit use for non-ruminant livestock.

Lablab purpureus

Lablab at KALRO-Naivasha (Photo: J. Ouda)

Strengths

- A dual purpose legume can be used with cereals in smallholder systems.
- High quality.
- As a green manure crop restores soil fertility
- Drought tolerant once established.
- High grain yields.
- Better root disease resistance than cowpeas
- Has considerable potential as a multipurpose legume in crop-livestock systems where rotations are possible.

Limitations

- Annual or short-lived perennial
- Poor frost tolerance.
- Host to pests attacking field beans.
- Indeterminate flowering leading to extended seeding period in current cultivars.

Compatibility (with other species)

In smallholder systems, lablab can be intercropped with maize. The lablab should be sown about 28 days after the maize to avoid severe cereal crop yield depression from competition.

Companion species

Grasses: Sorghums, millets and maize

Feeding value

Leaf has CP content of 21-38%, commonly about 26%. Much lower for stem (7-20%). Grain contains 20-28% CP. Digestibility ranges from 55-76%, commonly >60% (leaves). Grain high in vitamins A, B and C.

Palatability/acceptability

Leaf is highly palatable, but stem has low palatability. Palatability of grain is low to moderate depending on variety.

Toxicity

Leaf does not contain anti-nutritive factors such as tannins. Mixed plantings with forage sorghum prevents the occurrence of bloat. Grain contains tannins, and phytate and trypsin inhibitors. Concentrations vary among varieties. Soaking or cooking reduces the activity of these compounds.

Production potential

Seasonal yields of 2 t/ha leaf or 4 t/ha stem and leaf are common in sub-humid sub-tropics. Dry matter yield is usually higher than for cowpea, particularly under drought conditions. For human nutrition, 2-7 t/ha green pods. In monoculture, 1-2.5 t/ha DM, depending on cultivar.

Animal production

Good weight gain e.g. 350 g/head/day in zebu cattle fed maize stalk-lablab mixture achievable

Seed production

Intermittent flowering and pod production. Grain maturation on the forage cultivars is not uniform but crop landrace types often have more synchronous maturity. High grain yields of 1-2.5 t/ha, depending on cultivar, but when grown on trellises in smallholder systems the grain yields can be far greater. In mixtures with other crops, grain yields 0.5 t/ha. Late seeding varieties may be affected by early frosts. Lablab accessions with light coloured seeds have poor storage potential, which in turn affects seedling vigour and establishment

Desmodium

Desmodium at KALRO-Naivasha (Photo: J. Ouda)

Strengths

- For cooler regions.
- Long growing season.

Limitations

- Poor persistence especially under heavy grazing.
- Needs fertile soils.

'Silverleaf' variety is usually grown with grasses that are also cold-tolerant, for example Setaria, although it can combine with other tussock species. Can be grown with creeping grasses but does not persist under heavy grazing.

Companion species

- Grasses: Setaria sphacelata , Chloris gayana , Pennisetum clandestinum , Paspalum notatum
- Legumes: Desmodium intortum, Macroptilium atropurpureum.

Feeding value

Nutritional value is high although tannin levels can exceed 3%. This can act as 'by-pass' protein increasing the efficiency of digestion, but also slows nitrogen cycling from leaf drop.

Palatability/acceptability. The high tannin levels reduce palatability until stock acquire the taste for it.

Production potential

Legume yields of 4–7 t/ha and legume/grass yields of 15 t/ha DM have been recorded, with increases of 90–150 kg/ha in soil nitrogen.

Lucerne (*Medicago sativa*)

Lash Lucerne before flowering at KALRO-Naivasha (Photo: J. Ouda)

Uses/applications

Lucerne was one of the first forage crops to be domesticated. It is used as multi-purpose forage, able to be used for both grazing and conservation (hay, silage, meal and forage dehydration). It can be sown as a pure stand or in mixtures with both temperate and tropical grasses. The seed can also be used for human consumption as sprouts.

Feeding value

It is usually considered the 'King of Fodders' because it grows throughout the year if soil moisture is available. Protein and calcium levels are high, relative to other fodders, but metabolizable energy (ME) and phosphorus levels are low. ME and phosphorus levels are good in young growth but drop rapidly as the foliage matures. Intake of digestible nutrients by livestock is higher than for most other forages. Level of fibrous tissue is low and this allows rapid passage through the rumen. Lucerne foliage is highly digestible.

Palatability/acceptability

Lucerne is highly palatable. There are some cultivar differences in palatability and this is thought to be the result of different protein fractionations.

Toxicity

Bloat is the major limitation to grazing lucerne. A combination of management and control measures can be used to reduce the risk of animals bloating on lucerne. Hungry animals are more at risk of bloat so provide animals with access to a source of roughage before or during grazing. There is usually reduced risk of bloat in mixed stands under rain grown conditions. Access to anti-bloating agents (drenching, in their water supply, rumen capsules or sprayed on foliage) is essential in intensively grazed situations.

Production potential

Under irrigation, lucerne is capable of producing 25-27 t/ha dry matter in the first year of a stand and this can fall to as little as 8-15 t/ha by the third year. Production can be related to plant density, level of disease and pest resistance. Under rain-grown situations it is also determined by availability of soil moisture. Good irrigated stands can produce 20 t/ha of hay per year (allowing for at least one spoiled cut per year). An utilisation figure of 50% is expected under grazed conditions.

Animal production

When green feed is available, daily liveweight gains for beef cattle will be around 0.7 kg/head/day compared with 1 kg/head/day on oats, improved tropical pasture and native pasture. This reduced weight gain is a result of the lower energy availability. However lucerne grows throughout the year so, over the full year, supplementing native pasture with lucerne can increase gains from 0.5 to 0.7 kg/head/day at double the stocking rate. Irrigated lucerne can carry a beef cow and a calf on 0.5 to 1 ha on a year-round basis. Supplementing dairy cows grazing tropical grasses with lucerne can raise milk production from 10-12 to 14-15 L/cow/day. This can increase to 20 L/cow/day if the cows are further supplemented with grain to combat the energy deficiency. Sheep numbers can be increased from 6 to 15/ha by supplementing native pasture with lucerne. Irrigated lucerne can carry more than 80 dry sheep equivalents/ha from October to May.

Strengths

- Year-round production.
- High quality.
- Ability to extract water from deep soil layers.
- Persistent.
- Wide range of climatic adaptation.
- Responsive to irrigation.

Limitations

- Low energy levels.
- Restricted soil adaptation (fertile, well-drained).
- Cannot stand continuous grazing.
- Causes bloat.
- Susceptible to waterlogging.

2.4.3 SUB-MODULE 3: PASTURE AND FODDER CONSERVATION

To sustain production, availability of good quality feeds all year round is essential. Feed availability dwindles, particularly during the dry seasons and most farmers turn to crop residues. The crop-residues utilization is limited by low quality, often too low to support satisfactory milk production and reproduction performance. Poor handling at farm level further exacerbate deterioration of their feeding value. Poor handling (processing and poor storage) results in loss of palatability, quality decline and therefore ineffective utilization by the dairy cattle. As a result, the farm ruminants suffer severe nutritional stresses during the dry-season. This includes a whole range of consequences such as: low calving rate, low birth weight, high animal mortality (especially, that of calves), low weaning weight, reduced mature body size, low growth rate (delayed maturity) and more importantly low milk production. The feed shortage in the dry season is further compounded by farmers' lack of feed conservation skills. This impacts negatively on the overall household food security and income.

Poor conservation and utilization of maize stovers leading to poor dairy cattle performance (Photo: J. Ouda)

To alleviate the problem, it is important for farmers to embrace appropriate feed conservation practices. These include hay making, silage making, stover conservation, stover processing (e.g. by grinding).

Hay making

Livestock prefer fresh grass and other leay vegetation, but they can also eat dry grass or hay. To ensue enough feed is available especially during dry periods, grass and other forages can be conserved as hay. Farmers often use grass from areas restricted to grazing such roadsides and steep valleys. A farmer without cattle or with excess hay may also sell hay bales for income. The following are some tips of making good hay:

- Cut grass when it starts to flower. Both natural and planted grass and other fodders can be used
- Spread the grass on dry and clean surface where drying is not prohibited. This can last 2-3 days. Turn the grass so that it dries evenly and prevent rotting. This also ensures that destruction e.g. by insects (terminates) is detected and prevented
- Make sure the grass is not over heated by the sun, as over drying will destroy nutrients
- You may mix hay of a protein source forage with that of grass to boost quality
- Bale the dried hay. Bales are easier to transport and store than the loose hay. Mechanical baling is convenient where possible. For smallholders, manual baler can be used. A simple manual baler is made of rectangular box with an open top and bottom. To use the baler, place it on the ground. Lay two pieces of sisal twine across the box. Make sure the ends are long enough to be tied when the bale is ready. Put hay into the box and trample on it to compact thoroughly until the hay cannot be compacted any more. Bind strongly the finished bale with the twine.
- Store hay safely in a shed to protect it from the sun and rain. It should be stacked in a raised platform to away from pests. If a shed is not available, clear a patch of the ground and store the hay in a heap. Cover the hay to prevent moisture penetration and excessive sun.

Grass hay and Lucerne hay made by a smallholder dairy farmer
(Photo: T. Lanyasunya and J. Ouda)

Conservation of maize stovers

Maize is the third most produced grain after wheat and rice but leads in crop fodder production both globally and in Africa. Annual maize fodder yields have been estimated to be 1,816 and 340 million tonnes in the world and Africa, respectively. Maize is largely grown and left to dry to less than 20% grain moisture content before harvesting. The dry grain is a widely used staple in tropical regions. In Africa, many communities differently prepare 'porridge' and 'cakes' from maize meal e.g. 'Ugali', 'Fofo', 'Kita' and 'Pap' which are popular in East, West, North and South Africa, respectively.

Harvesting maize at dry grain stage widely practiced (Photo: J. Ouda)

Harvesting maize at grain milk stage for human food (roasting and boiling) is also popular. Stovers harvested at grain milk are greener and more appealing to ruminants, hence generally have high palatability. More importantly, they have been shown to have higher nutritive quality due to lower fibre content as compared to stovers harvested at later maturity stage.

Maize harvested at grain milk stage suitable for food (Photo: **J**. Ouda)

Given that maize stover is potentially an important source of roughage for dairy cattle production, improvement in their utilization is expected to result into considerable positive impact on the overall productivity.

Conservation of maize stover

Maize ready for harvest showing high proportion of leaves (Photo: J. Ouda)

Maize stovers can be conserved in the field in pyramidal heaps that reduce chances of penetration by rain water and direct sun heat. The leaf is the most nutritious component of maize stovers hence it is important to prevent loss of leaves in the process of conservation.

Maize stovers conservation in the field for utilization by livestock (Photo: J. Ouda)

There are high chances of pest, especially insects attack on stored maize stovers. Thus there should be regular inspection of the stored stovers and corrective measurements undertaken in case of such damages

Damage of conserved maize stovers by pests (Photo J. Ouda)

The bulkiness of maize stovers limits intake. Processing the stovers by grinding enhances the intake and prevents losses due to pests.

Chaff cutter (can be used to chop maize stovers (Photo: T. Lanyasunya)

Chopped/grinded stovers should be stored safely with regular inspection to monitor any spoilage e.g. mould growth or rotting

Processing and conservation of maize stovers (Photo: J. Ouda and T. Lanyasunya)

Making pit silage

Silage is fermented crop of grass or other green material. Forage, grown in the wet season, can be stored as silage to be fed to the cows in the dry season, when there is no fresh forage available. The store must be airtight to prevent loss

of nutrients and the formation of mould. Silage can be made in plastic bags or pits.

Steps in making silage

The crop should be ready to harvest: The seed of forage sorghum or maize to be soft but not milky when you squeeze it open

- Napier grass needs to be about a metre high (up to a man's waist)
- If there are legumes growing between the crop or bana grass, make sure the legumes have young pods which are not dry.
- If it has been raining and the forage is wet, or if the forage seems immature (the seed is very milky) then it is best to harvest it and leave it in the sun for a few hours to wilt (too much water in the forage can spoil the silage).
- The chopping and bagging area or silage pit must be clean and ready for the forage. If possible, a big piece of plastic should be spread out as shown below
- Ensure proper compaction whether pit or bag silage is being made

Chopping and bagging of silage material

Part of Pit silage making (companion process (Photo: J. Ouda)

- Seal the silage material by ensuring no air can penetrate. Silage is formed through anaerobic fermentation by microorganisms.
- Carefully and step by step open a small portion of the silage when need arises for feeding and seal the remaining silage immediately after the removal.

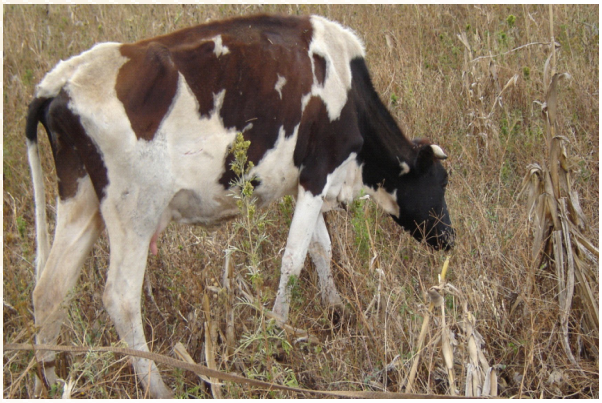
Sorghum silage made in a pit by smallholder dairy farmer (Photo: J. Ouda)

2.4.4 SUB-MODULE 4: FORMULATION OF CATTLE RATIONS

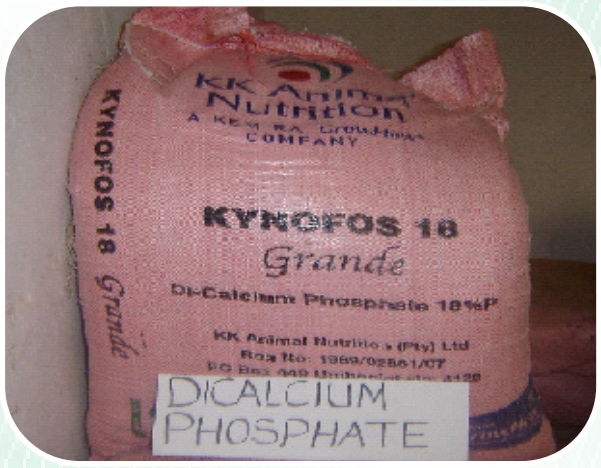
Cattle production is a serious business. However, in most cases farmers are not able to meet family needs because of low profit margins. High cost of feeds and low levels of production are some of the reasons livestock keepers are not making the expected profits which is attributed to poor diets. About 50-70% of cost of dairy production is made up of cost of feeds. Inadequate nutrition is a major cause of low live-weight gains, infertility and low milk yields in dairy cattle. These problems are directly related to late weaning of calves, delayed time of breeding and low lactation milk yields.

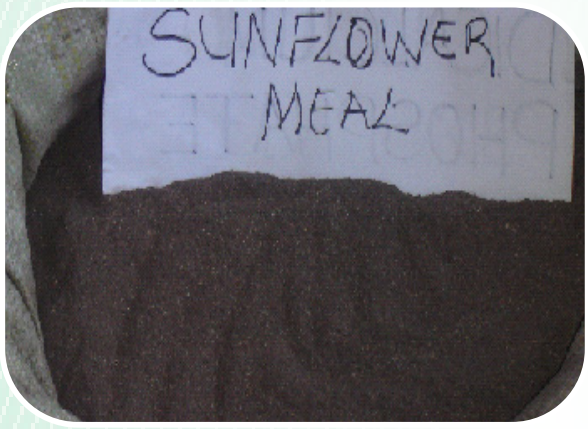
Poor dairy cattle feeding practices result from lack of information, skills and knowledge on modern methods of feeding different classes of dairy stock and at different physiological stages by the farmer. Majority of farmers are not aware of the different nutrient requirements for the various classes of dairy stock which may result to either overfeeding or underfeeding of the dairy cattle and hence wastage of scarce feed resources. Additionally, most farmers are not aware of the quality of the available feed resources and how to use the information of quality of feeds to improve dairy production. Evidently lacking is the ability by farmers to mix the various feed ingredients to meet nutrient requirements for maintenance and production of dairy cattle.

Balanced dairy cattle rations can be formulated using various methods (Pearson square, simultaneous equations, least cost formulation using computer models). Although use of theese methods give more accurate and reliable dairy cattle rations, the methods are complicated and of no benefit to majority of dairy farmers with limited education. This is further compounded by lack of simplified extension materials to enhance farmer's capacity to formulate balanced dairy cattle rations using locally available feed resources.



A dairy cattle with good nutrition status (left) and a poorly nourished (right) (Photo: J. Ouda)





Feeds resources commonly available in Kenya (Photos: J. Ouda and J. Muia)

Nutrients required by dairy cattle

Energy. Energy is the fuel that keeps all body functions going. Milk production requires a lot of energy. If energy in the ration is not enough, the cow will lose body condition and for milking cows, milk yield will drop, pregnant cows become ill after calving and the calf is usually small in size.

If there is excess energy in the ration, the cow becomes too fat. Cows that are too fat at calving usually have difficult births, retained placenta, displaced abomasums, suffer from milk fever and ketosis.

Sources of energy are roughages and concentrate supplements fed to dairy cattle. Roughages form the main bulk of the dairy cow ration. Roughages are bulky feeds that have a low weight per unit volume. Generally feedstuffs with more than 18% crude fibre and low digestibility are considered roughages.

A high yielding cow may not have enough capacity to consume the amount of roughage required to supply the total energy required due to rumen size. For this reason, supplementation is recommended. Examples of energy sources

(Forages and fodders, agricultural by-products, and concentrates) are shown in Tables 2.42 and 2.43.

TABLE 2.42. ROUGHAGES FED TO DAIRY CATTLE AND THEIR QUALITY

Forage/Fodder	Dry matter (g/kg)	ME Energy (MJ/kg DM)	Crude Protein (g/kg DM)	Calcium (g/kg DM)	Phosphorus (g/kg DM)
Napier grass	180	8.5	88	5.0	3.0
Rhodes grass	280	8.5	90	-	-
Napier silage	280	9.0	75	-	-
Maize cobs	900	7.5	30	1.2	0.4
Fodder sorghum dry	890	8.9	75	4.0	2.1
Maize silage	320	10.5	80	4.0	2.7
Kikuyu grass	200	9.5	120	-	-
Rhodes hay	850	9.2	80	-	-
Lucerne hay	865	8.5	170	14.0	2.4
Sesbania leaves	260	8.5	260	22.1	2.8
Calliandra leaves	260	8.5	240	11.1	1.4
Leucaena leaves	280	8.4	230	15.5	2.1
Sweet potato vines	100	8.0	160	17.9	2.4
Green maize stalks	300	9	80	5.0	2.5
Maize stover	850	7.5	45	3.5	1.9

TABLE 2.43. CONCENTRATES AND MINERALS SUPPLEMENTED TO DAIRY CATTLE AND THEIR QUALITY

Concentrate/Mineral	Dry matter (g/kg)	ME Energy (MJ/kg DM)	Crude protein (g/kg DM)	Calcium (g/kg DM)	Phosphorus (g/kg DM)
High yielder dairy meal	920	12.0	180	-	-
Dairy meal	950	12.0	165	6.0	4.0
Calf pellets	920	12.0	180	-	-
Cotton seed cake	920	13.5	350	1.9	2.0
Maize germ	900	15.5	106	1.0	0.5
Maize bran	900	11.5	115	1.0	2.0
Wheat pollard	900	15.1	160	1.3	9.0
Fish meal (Omena)	880	15.0	470	60.0	32.0
Fish meal (Buta)	900	13.4	400	60.0	20.0
Poultry litter	880	10.6	160	-	-
Urea	950	0.0	2600	-	-
Brewers Yeast	930	12.6	340	1.0	14.0
Brewers grains	210	10.5	254	3.3	5.5
Magic protein	900	11.9	480	-	-
Wheat bran	890	11.2	140	1.4	13.8
Maize meal	860	13.8	102	-	-
Cassava tuber meal	840	15.7	30	3.0	3.5
Lupins	860	14.2	342	-	-
Sunflower seed cake	940	12.5	360	3.0	9.0
Soya bean meal	900	12.4	470	-	-
Molasses	750	12.2	35	9.0	1.0
Maclick super	980	-	-	185.1	110.0
Limestone	100	-	-	340.0	0.2
Dicalcium phosphate	970	-	-	220.0	193.0

Protein. Protein provides the essential chemical building blocks for the body cells and tissues, including muscles, blood, skin, internal organs, and also to make milk. Cows can make protein from non-protein nitrogen containing materials such as Urea and poultry litter. Cows can not store much protein in their bodies and so it must be supplied in the daily ration in order to maintain high milk production.

If the amount of protein in ration is suddenly reduced, milk production will drop rapidly and the cow will lose weight, growth rate of calves and heifers will be reduced also. Feeding too much protein to dairy cows is wasteful because the excess is broken down by micro-organisms in the rumen and excreted from the body. This is wasteful and is unlikely to happen since protein is very expensive.

Minerals. Minerals are required in small amounts than the other nutrients but are important components of the ration. They are essential for cows to remain healthy and for the body to function properly, for the development and maintenance of strong bones and for successful reproduction and production of milk.

Dairy cows require more of the macro-minerals (Calcium, Phosphorus, Magnesium, Sodium, Potassium, Chlorine, Sulphur) than the micro-minerals (Iodine, Iron, Cobalt, Copper, Manganese, Molybdenum, Zinc, Selenium).If cows do not consume enough of the macro-minerals, this will cause reduced milk yield, infertility problems, weakness of the bone and increased incidences of non-infectious diseases such as milk fever (Due to insufficient Calcium).

Deficiencies in micro-minerals (Trace elements) can cause a variety of diseases and conditions depending on which mineral is deficient. Cattle grazing in areas around Nakuru usually have Cobalt deficiency and may develop a wasting disease called Nakuritis. They become anemic and eventually die. The forages are deficient of mineral Cobalt because the soils naturally contain very low levels of this micro-nutrient. Special mineral supplements are available for cattle in such areas. Too much of the micro-minerals can cause poisoning.

Two macro-minerals are of particular importance. These are Calcium and Phosphorus and special attention should be given to the two minerals when formulating rations. Legumes tend to have more Calcium and Phosphorus than grasses. Grains are low in Calcium. Young dark green forage tends to have more minerals than old, dry and yellow forages. Most tropical forages are low in Phosphorus.

Extra Calcium and Phosphorus usually need to be provided in the ration over and above that naturally present in the feed and mineral mix, especially for high yielding animals. Tables 2.4.1 and 2.4.2 show examples of sources of mineral salts (Forages and fodders, agricultural by-products, concentrates and minerals).

Vitamins. These are group of substances that are required in the ration in very small amounts for normal function of the body. Insufficient supply of any vitamin results in specific deficiency disease. Vitamins are usually not added to dairy cattle rations because most of them are obtained from green forages and some are made in the rumen by micro-organisms.

Feed additives. A feed additive is defined as a feed ingredient of non-nutritive nature that stimulates growth or other type of performance or improves the efficiency of feed utilization or that may be beneficial in some manner to the health or metabolism of the animal. Examples of feed additives for dairy cattle are anti-helmintics (Dewormers), anti-bloat agents, rumen buffers ($NaHCO_3$, MgO), flavouring agents (Molasses), rumen microbes for fibre digestion (Yea sac) and growth promoters or hormone-like substances. In Kenya, feed additives are not commonly added to dairy cattle rations.

Water. Animals need water for normal functioning of their body. Water is needed to make saliva for swallowing feed and for chewing the cud, for feed to be digested, to cool the body when it is too hot and to remove waste materials from the body in the urine and faeces. In addition a milking cow needs water for milk production.

It takes 5 litres of water to produce 1 litre of milk. Ideally, water should be available to dairy cattle at all times. If this in not possible, a rule of thumb is to supply 1litre of water for every 10 kg of live-weight of the cow plus 1.5 litres of water per 1 litre of milk produced.

Information required in formulation of balanced dairy cattle ration. In the long-term commercial dairy production in Kenya will be promoted through training of dairy farmers, extension workers and feed manufacturers on the use of

inexpensive locally available dairy feeds. In the short-term, feed formulation should be simplified.

Available feedstuffs and their quality. One should have a good knowledge of the feedstuffs available within the farm and those purchased from outside the farm. The quality of all available feedstuffs including forages and supplements should also be known. If the information is not readily available feed samples need to be taken for quality determination in a reputable laboratory. Examples of various types of dairy cattle feedstuffs and their quality are provided in Table 2.42 and 2.43.

Containers of known weight used to weigh feed resources in a ration (Photo: J. Ouda)

Cost of feedstuffs in relation to milk prices

For commercial dairy production it is important that profit margins are maintained. This could be achieved by either increasing the levels of production at a rate higher than the increasing cost of production or maintaining levels of production but at a lower cost of production. For this to happen, farmers must be aware of the costs of feedstuffs

particularly the commercial concentrates and the price of milk and dairy products. Table 2.44 shows price of milk and cost of feed ingredients in different parts of Kenya.

TABLE 2.44. PRICE OF MILK AND FEED INGREDIENTS IN DIFFERENT PARTS OF KENYA (2008)

District	Price of milk (Ksh/litre)	Cost of Maize germ (Ksh/kg)	Fish meal (Ksh/kg)	Cost of Maclick super (Ksh/kg)
Kiambu	20.00 - 28.00	9.00 – 10.00	32.00 – 37.00	83.00 – 88.00
Nyandarua	12.00 – 15.00	10.00 -10.80	35.00 – 43.00	85.00 – 90.00
Bureti	14.00 – 18.00	10.50 – 11.00	36.00 – 45.00	87.00 – 92.00
Machakos	22.00 – 30.00	10.00 – 10.80	35.00 – 43.00	85.00 – 90.00

Live-weight of dairy cattle

The amount of feed which will provide adequate nutrients to animals will depend on their body size (live-weight). Farmers are not able to determine live-weight of their cattle because they do not have weighing scales. Table 2.45 gives data which can be used by farmers to estimate live-weight of their cattle from girth measurements.

Estimation of cow body weight using heart girth measurement (Photo: J. Muia)

TABLE 2.45. ESTIMATION OF LIVE-WEIGHT (KG) OF DAIRY CATTLE USING CHEST GIRTH (CM) MEASUREMENTS

Calves		Heifers		Cows	
Girth size	Live-weight	Girth size (cm)	Live-weight	Girth size	Live-weight
45	15	108	112	172	420
47	17	110	118	174	435
49	19	112	124	176	451
51	21	114	130	178	467
53	23	116	137	180	483
55	25	118	143	182	500
57	27	120	150	184	516
59	29	122	158	186	534
61	31	124	166	188	552
63	33	126	174	190	570
65	35	128	182	192	590
67	37	130	190	194	610
69	39	132	198	196	631
71	41	134	206	198	653
73	43	136	214	200	675

TABLE 2.45. ESTIMATION OF LIVE-WEIGHT (KG) OF DAIRY CATTLE USING CHEST GIRTH (CM) MEASUREMENTS

75	45	138	222	202	697
77	47	140	230	204	720
79	49	142	240	206	
81	51	144	248	208	
83	55	146	256	210	
85	59	148	264	212	
87	63	150	272	214	
89	67	152	280	216	
91	71	154	290	218	
93	75	156	301	220	
95	79	158	313	222	
97	83	160	325	224	
99	87	162	353	226	
101	92	164	366	228	
103	98	166	378	230	
104	103	168	392	232	
106	106	170	406	234	

Maximum dry matter intake

Animal feedstuff can be divided into two major components namely dry matter and water. The dry matter component consists of organic and inorganic matter. The organic matter consists of carbohydrates (source of energy), lipids and fats (source of energy), protein and vitamins. The inorganic matter is the source of macro- and micro-minerals. Since all nutrients are contained in the dry matter the animal must consume this portion in adequate amounts to obtain the required nutrients. If a feed is high in moisture, the animal may not be able to consume enough of the feed to obtain the required nutrients due to limitation of rumen space. Table 2.46 shows the maximum dry matter intake by dairy cattle of various live-weights.

Dairy cattle under stall feeding (Photo: J. Ouda)

TABLE 2.46. ESTIMATED MAXIMUM DAILY DRY MATTER INTAKE BY DAIRY COWS (KG)

Milk yield (4% Butter-fat)	Cow live-weight (kg)					
	350	400	450	500	550	600
10	10.5	11.0	11.5	12.0	12.5	13.0
15	12.0	13.0	13.5	14.0	14.5	15.5
20	13.5	14.5	15.5	16.0	17.0	17.5
25	15.0	16.0	17.0	17.5	18.5	19.5
30	16.5	17.5	19.0	19.5	20.5	21.0
35	19.0	20.0	20.5	21.0	22.0	22.5
40	21.0	22.0	22.5	23.0	24.0	24.5

Maximum dry matter intake may also be estimated from the following equations. Maximum daily dry matter intake (kg/cow) = 0.025 (Live-weight in kg) + 0.1 (Kg of daily milk yield) or 3.0 – 3.5 % of live-weight of cow. If the butter-fat (BF) content of milk is not different, then the following equation can be used to estimate milk yield at 4% butter-fat:

- Kg of 4% BF corrected daily milk yield = 0.4 (Kg of daily milk yield) + 15 (Kg of fat in daily milk yield).

Nutrient requirements for maintenance

The nutrient requirements for maintenance of animals are influenced by their live-weight, activity (e.g. walking long distance) and environmental temperature (too cold or too hot). Table 2.47 shows nutrient requirements for maintenance of dairy cattle of various live-weights.

TABLE 2.47. DAILY NUTRIENT REQUIREMENTS FOR MAINTENANCE OF A DAIRY COW

Cow live-weight (kg)	ME Energy (MJ)	Crude protein (g)	Calcium (g)	Phosphorus (g)
350	45.5	294	14	10
400	50.3	318	16	11
450	54.9	341	18	13
500	59.4	364	20	14
550	63.8	386	22	16
600	68.1	406	24	17

Nutrient requirements for growth

The amount of nutrients required by an animal is equal to the nutrients in the tissue gained. Nutrients concentrations in deposited tissue are influenced by the animal rate of weight gain and the stage of growth or live-weight. The nutrients required for growth by dairy cattle of various live-weights are given in Table 2.48.

TABLE 2. 48. DAILY NUTRIENT REQUIREMENTS FOR GROWTH OF DAIRY CATTLE

Live-weight (Kg)	Daily gain (g)	ME Energy (MJ)	Crude protein (g)	Calcium (g)	Phosphorus (g)
Calves					
25	200	8.4	84	6	4
30	300	11.3	112	7	4
50	500	27.2	315	10	6
75	600	33.4	387	14	8
Heifers					
100	400	26.5	386	15	8
100	500	29.0	422	16	8
100	600	31.5	458	17	9
150	400	35.1	529	17	10
150	500	38.2	575	18	11
150	600	41.3	622	19	11
200	400	43.5	598	19	13
200	500	47.1	648	20	13
200	600	50.8	718	20	14
250	400	51.7	629	21	15
250	500	56.0	682	21	16
250	600	60.4	753	22	16
300	400	60.2	761	22	16
300	500	65.2	824	23	17

TABLE 2. 48. DAILY NUTRIENT REQUIREMENTS FOR GROWTH OF DAIRY CATTLE					
300	600	70.3	888	23	17
350	400	69.1	909	23	17
350	500	74.8	985	23	18
350	600	80.7	1062	24	18
400	400	78.5	1078	24	18
400	500	85.2	1169	24	19
400	600	92.0	1263	25	19
450	400	89.0	1276	27	19
450	500	96.7	1387	28	19
450	600	104.6	1500	28	19
Lactating cows					
	1000	35.8	320	-	-

Nutrient requirements for milk production

When feeding a dairy cow the aim should be to maximize milk yield by meeting cow's feed requirements. Requirements for milk production will depend on the amount of milk produced by the cow, energy content of milk which is indicated by fat content (the higher the fat content the higher the energy required). Table 2.49 shows nutrient requirements for producing 1 kg of milk of various butter fat contents.

TABLE 2.49. NUTRIENT REQUIREMENTS FOR PRODUCTION OF 1 KG OF MILK				
Milk BF (%)	ME Energy (MJ)	Crude protein (g)	Calcium (g)	Phosphorus (g)
3.0	4.5	78	2.7	1.7
3.5	4.8	84	3.0	1.8
4.0	5.2	90	3.2	2.0
4.5	5.5	96	3.5	2.1
5.0	5.9	101	3.7	2.3
5.5	6.2	107	3.9	2.4

In addition to nutrient requirements for milk production nutrients will also be required to cater for other functions such as reproduction (pregnant cows require more to cater for growth of calf) and growth rate if she is not mature (in case of first calf cows).

Water requirements

The amount of water dairy cattle will drink is influenced by the quantity of dry matter ingested, composition of the diet, characteristics of the water, environmental temperatures and physiological state of the animal. Table 2.50 shows water requirements for dairy cows at different ambient temperatures based on dry matter intake requirements for production of 20 kg milk per day.

TABLE 2.50. WATER REQUIREMENTS FOR DAIRY CATTLE							
Temperature °C							
5		10	15	20	25	30	35
4.4		4.6	4.8	5.0	5.2	5.4	5.6
Live-weight (kg)							
350	59.4	62.1	64.8	67.5	70.2	72.9	75.6
400	63.8	66.7	69.6	72.5	75.4	78.3	81.2
450	68.2	71.3	74.4	77.5	80.6	83.7	86.8
500	70.4	73.6	76.8	80.0	83.2	86.4	89.6
550	74.8	78.2	81.6	85.0	88.4	91.8	95.2
600	77.0	80.5	84.0	87.5	91.0	94.5	98.0

Ration formulation guidelines

Dairy farming is a serious business and therefore farmers need to make profit in order to meet family needs. Feed rations fed to dairy cattle either originate from the farm or are purchased. In order to minimize feed wastage and to overcome the problem of low levels of production, dairy rations need to be efficiently utilized by the animal. A cow fed on balanced ration will utilize the feed more efficiently and hence it production will be better than a cow fed on imbalanced rations. Feed rations that are offered to dairy cows are considered balanced if they provide adequate nutrients (Carbohydrates, protein and minerals) to meet the animal requirements for maintenance, reproduction, growth and milk production.

Proportions of basal diet and supplement in a dairy cow ration

The cheapest feed for milk production is good quality roughage. However, quality of roughage fed to dairy cattle is usually low resulting in sub-optimal levels of production. Further increase in production can therefore be achieved by the use of supplements. Among the factors influencing the quantities of roughage and supplements offered are their quality and level of production of dairy cattle. Table 2.51 shows simple guidelines on proportions of basal diet and supplements depending on levels of milk production in dairy cattle.

TABLE 2.4.51. PROPORTION OF BASAL DIET AND SUPPLEMENTS IN DAIRY CATTLE RATIONS

Milk yield (kg/day)	Basal diet DM (%)	Supplement DM (%)
10-14	70	30
15-19	60	40
20-24	50	50
25-29	40	60
30-34	30	70
35-40	20	80

Total mixed rations (TMR's)

Dairy cattle feeding as practiced by most farmers (roughage feeding followed by concentrate feeding at milking), may not meet all the nutrient requirements of the animal. Fluctuations in rumen fermentation and supply of nutrients to the mammary glands occur when basal diet and concentrates are offered to dairy cattle at different times. This has a negative effect on productivity of the animal because requirements are met mostly for one nutrient and not the other nutrient and thus the ration is not balanced. To overcome this problem, a total mixed ration can be formulated at 66% for Rhodes hay, 33% for dairy meal and 1% for Malick Super are recommended (Tables 2.52).

TABLE 2.52. TOTAL MIXED RATION MADE FROM SEVERAL FEED INGREDIENTS (DM BASIS)

Feedstuff	**%**
Napier grass	65
Lucerne hay	4
Maize germ	18
Wheat pollard	4
Soya meal	2
Cotton seed cake	6
Maclick super	1
Total	100

Limitations of TMR's

- Lack of technical skills and knowledge by farmer and extension officers
- Narrow feed resource base at farm level

- Cost of feed ingredients, processing and mixing equipment may be high for small scale farmers

Advantages of TMR's

- Nutritional balanced diet is supplied to the animal 24 hours a day for maximum productivity
- Convenience of feeding a single meal per day
- Minimise selection and hence wastage of feed by the animal Proportions of energy, protein and minerals in concentrates

Concentrates are needed to promote better utilization of low quality roughage and increase dairy production. Since availability and cost of commercial concentrates are limiting factors to small holder dairy production, formulation of inexpensive home-made concentrates is a necessity. Various combinations of feed ingredients including energy feed (%), protein (%) and mineral (%) can be compounded depending upon the costs of ingredients and costs per unit protein and energy. An example of how to mix a high yielder home-made concetrate would include maize germ (66%), cotton seed cake (20%), poulyrt litter (8%) fish meal (4%) and Maclick Super (2%).

Formulation of rations using a single Pearson square

Assume you want to make a dairy meal with 16% crude protein (CP) using cotton seed cake (CSC) and maize germ (MG). The CSC provides 35% CP while MG provides 10.6% CP. Arrange the information as shown in the square below. In the middle of the square is desired value of the nutrient. On the left are the two ingredients with their nutrient content. Subtract diagonally (lesser from the larger) or disregard the sign.

CSC 35 % 5.4 parts CSC [i.e. 10.6 – 16 = 5.4 (disregard the sign)]

- 16 %
- (desired)
- Maize (10.6 %) 19 parts MG [i.e. 35 – 16 = 19 (disregard the sign)]
- Total 24.4 parts

Mix 5.4 parts of CSC with 19 parts of MG expressed as % (100 kg feed) giving:

- 5.4/24.4*100 = 22.1 % of CSC
- 19/25*100 = 77.9 % of MG
- Check to confirm the CP value.
- CSC 22.1*35/100 = 7.74
- MG 77.9*10.6/100 = 8.26
- Total 16

One ingredient must be higher in the nutrient (e.g 35% CP for CSC) than the desired value (e.g. 16 % CP for dairy meal). The other ingredient must be lower in the nutrient (e.g. 10.6% CP for MG) than the desired value for dairy meal. No ration can be mixed with a higher value than the highest of the ingredients or vice versa. This method balances only one nutrient from two feedstuffs at a time

Formulation of rations using several Pearson square

In many instances, more than two feedstuffs and for more than one nutrient need to be balanced. A double Pearson square method may be used with four feedstuffs and two nutrients. This is accomplished using three Pearson squares.

Example: Make a ration for a lactating cow of 18% CP and ME of 12.0 MJ/ kg DM of ME using MG (10.6% CP and 15.5 MJ/ kg DM), Poultry litter (PL) (16% CP and 10.6 MJ/ kg DM), Cotton seed cake (35% CP and 13.5 MJ/ kg DM) and Soyabean meal (47% CP and 12.4 MJ/ kg DM).

Normally, two sets of a high energy and a high protein concentrates are chosen. The first two Pearson squares are used to balance for the first nutrient in both sets. The densities of the second nutrient in either mixture are calculated. Then the two mixtures are balanced in the third set for the second nutrient.

Mix 1: CP=18%, ME>12.0 MJ/ kg DM

- MG 10.6% 17 = 70% (MG)
- 18

CSC 35% 7.4 = 30% (CSC)

- Total 24.4

Note: for ME to be >12.0 MJ/kg DM, MG must be used. For CP = 18%, either CSC or soybean (SBM) can be used. Compute for ME in mix 1.

- MG (70*15.5/100) + CSC (30*13.5/100) =14.9 MJ/ kg DM

Mix 2: CP=18%, ME< 12.0 MJ/kg DM

- 29= 93.5% (PL)
- PL 16%
- 18%
- SBM 47% 2 =6.5% (SBM)
- Total 31

Compute for ME

- PL (93.5*10.6/100) + SBM (6.5 *12.4/100) = 10.7 MJ/ kg DM

Mix 3: CP=18%, ME=12.0 MJ/ kg DM

- Mix 1 = 14.9 1.3 = 31.0% (Mix 1)
- 12.0
- Mix 2 = 10.7 2.9 = 69.0 (Mix 2)
- Total 4.2

Calculate ingredient composition

To avoid mixing three times, calculate the ingredient composition of the final mix.

Final mix of raw materials when two nutrients are balanced is shown in Tables 2.53 and 2.54

TABLE 2.53. RAW MATERIALS WHEN TWO NUTRIENTS ARE BALANCED

Ingredient	Mix 1	Mix 2	Amount of Mix 1 in Mix 3	Amount of Mix 2 in Mix 3	Final composition of ration
Maize germ	70	0	31.0	0	70*31.0/100 =21.7
Poultry litter	0	93.5	0	69.0	93.5*69.0/100=64.5
Cotton seed cake	30	0	31.0	0	30*31.0/100 =9.3
Soy bean meal	0	6.5	0	69.0	6.5*69.0/100 =4.5

TABLE 2.54.CHECK FOR ME AND CP					
Ingredient	% In Ration	CP %	ME, MJ/kg DM	CP contribution	ME contribution
Maize germ	21.7	10.6	15.5	2.3	3.4
Poultry litter	64.5	16.0	10.6	10.3	6.8
Cotton seed cake.	9.3	35.0	13.5	3.3	1.3
Soybean meal	4.5	47.0	12.4	2.1	0.6
Total				18.0	12.1

Formulation of rations using an alternative procedure

If the following information is provided, a cow weighing 450 kg and producing 20 kg/day of milk (4% butter fat) is fed on a basal diet of Napier grass supplemented with dairy meal and Maclick super. How much of the Napier, dairy meal and minerals will meet the cows requirements.

STEP 1. From Table 2.53 estimate maximum dry matter intake for a 450 kg cow producing 20 kg of milk (4% butter fat) = 15.5 kg

STEP 2. From Table 2.54 estimate proportions of Napier and dairy meal for a cow producing 20 kg/ day of milk

- Napier grass = 15.5*50/100 = 7.75 kg
- Dairy meal = 15.5*50/100 = 7.75 kg

STEP 3. From estimate nutrients supplied by the feedstuffs (Table 2.55) and from estimate nutrient requirements by a 450 kg cow producing 20 kg/ day of milk (4% butter fat)

TABLE 2.55. NUTRIENTS SUPPLIED BY FEEDS AND REQUIREMENTS TO PRODUCE 20 KG/ DAY OF MILK					
	DMI (Kg/day)	ME (MJ/kg)	CP (g/day)	Ca (g/day)	P (g/day)
Feedstuffs	15.6	155.8	1938	102.1	64.2
Requirements	15.6	158.9	2141	82.0	53.0
Difference	0.0	-3.1	-203	+20.1	+11.2

STEP 4. Estimate amount of feed to be fed to the cow per day

- Napier = 7.75*1000/180 = 43.1 kg fresh Napier
- With 5 % wastage allowance = 43.1 + (43.1*5/100) = 45 kg of fresh Napier
- Dairy meal = 7.75 = 8.0 kg
- Maclick = 100 g

Formulation of rations using computer software

Feeding standards are considered as minimum; hence the final mix should have at least the stated amounts. The Pearson square and the alternative method cannot give a least cost formulation.

Where more than two feed ingredients are available and more than two nutrients must be balanced and costs must be considered then linear programming (LP) must be used. The technique allows for simultaneous consideration of economical and nutritional parameters. The formulator must have a good understanding of the specifications and the

techniques of formulation so as to enable interpretation of results.

Most of the performance drill of linear programming is a black box but it is good to know the basic concept to enable verification, interpretation and reformulation of formulas when necessary.

A host of LP programs are available. In LP the fewer the constraints the more accurate are the results. But because of nutritional considerations these are necessary. However, with each additional constraint, cost of feeds increases.

Advantages of least cost formulation

- Avail cheap supply of nutrients
- Avoid unnecessary costs when one ingredient's price increases
- Determines critical price ranges before reworking the problems

2.4.5 SUB-MODULE 5: GOAT PRODUCTION

Meat goats rearing

Meat goat farming is becoming popular in Kenya. This is because goats are hardy and can be kept in dry and marginal areas. Most farmers venture into meat goat rearing as a source of income from the sale of extra kids and culled adults. This is because goats are prolific breeders compared to cows. They have a short gestation period, high chances of twinning and requires less space and feed less than cows. They are also much easier to invest in considering the initial capital investment and time needed to attend to them. They are generally browsers and feed often on fodder trees.

Breeds. These are the common breeds suited for commercial goat farming in Kenya:

- Small East African Goat
- Galla Goat
- Anglo-Nubians
- Kenyan Alpine
- Boer

Housing. A suitable goat house should be constructed as indicated below:

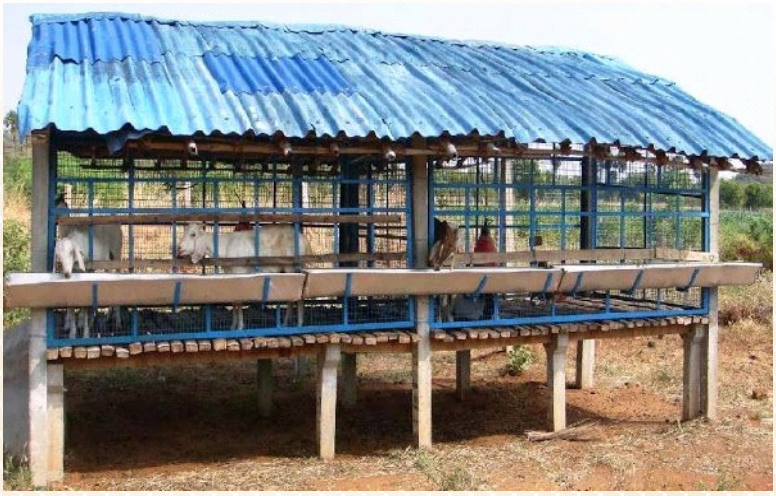
- Adequate space to accommodate each goat with an adult goat being provided an average space of 0.5 - 0.75 square metre,
- Be damp proof and the roof not leaking,
- Free from sharp objects, pests and wild animals,
- Provide for proper ventilation.

The house should be divided into two parts:

Resting or sleeping area - Make the sleeping area comfortable enough for the goats with sufficient ventilation system; soft bedding; proper roof; and well secured with a wall and door.

Feeding area - The feeding area should have water trough, feed trough, slatted floor, feed racks and a rain proof mineral block pack area.

The feed area and feeding places should have sufficient flow of fresh air and light. Since goats are browsers and not grazers, a house 1.5 feet raised off the ground would be appropriate and reduces feed wastage. A house of 1.8 metre *1.8 metre* 2.5 metre (5.5 ft * 5.5 ft * 8.5 ft) is suitable enough for housing 10 goats.



Goat housing

Feeding

Meat goats should be fed complementary on fast growing and quick weight gaining food. These include:

Fodder: The fodder mainly Napier grass and green leaves should be chopped into small pieces of size 3 cm. The feed should include energy supplements, molasses, milling by-products like pollard, bran, cereals etc.

Protein supplements: These include calliandra leaves, cotton seed cake, leucaena leaves, desmodium, fish-meal, dairy meal, sweet potato vines etc.

Salt: Hang nutritious salt lick like Maclik Mineral Brick constantly in their cages to lick. This will avoid cases of difficulties in urination and minimize cases of bloody urine.

Water: Ensure goats get sufficient supply of clean and fresh water. An adult goat should take 2 litres of water per day.

The goats should be castrated for fast weight gain; ideally at the age of three weeks.

Since feed costs account for up to 70% of the total cost in a meat goat enterprise, costs can be reduced through adequate year-round browsing and/or grazing, with only mineral supplementation. Goat feeds include hay, crop by-products such as maize stalks and forages from leucaena, calliandra, gliricidia, clitoria and centrosema, mango tree leaves and cowpea leaves. Local bran from maize and other grains may be used as energy supplement. Cassava leaves may be fed to goats but only after leaving them under the sun for one day to reduce poisoning;

Vaccination

Timely vaccination of meat goats is essential for a healthy flock. Vaccination keeps goats free from highly contagious diseases like PPR (Peste des Petits ruminants) plague), CCPP (Contagious Caprine Pleuropneumonia) goat pneumonia, tetanus etc. The following vaccination and disease management schedule should be ensured to maintain a healthy flock:

Vaccination schedule

Age	Vaccinate against	Application	Remarks
1 month and above	CCPP (goat pneumonia)	S/C Annual vaccinations	Only for goats, Sheep are not affected
2 weeks and above	PPR (goat plague)	S/C Properly done once in a lifetime will do. Newborns should be vaccinated as a routine	Came to Kenya in 2006 - related to rinderpest. If no vaccination the disease can kill all your goats and sheep.
2 weeks and above	Sheep and Goat pox	S/C Annual vaccinations	If no vaccination this disease may kill lambs and kids. In serious cases mortality may be high.

2 weeks and above	Enterotoxemia + tetanus	S/C Every 6-8 months. Disease is common with lush pastures	Pregnant animals should be vaccinated at least a month before giving birth. Vaccination for tetanus should always follow tail docking
1 month and above	Orf	Scarification method. If there is a risk of outbreak or. In endemic areas routine vaccination is recommended	Orf may be more common in goats due to their feeding habits as browsers of thorny bushes. Mortality of young can be high. Repeat vaccination should be done 2-3 months after the initial one. The vaccine is live and can affect people (to HANDLE WITH CARE).
3 month and above	CCPP Contagious Caprine Pleuropneumoni a	S/C Annual vaccinations	Only for goats, Sheep are not affected

Tick control: Tick control involves washing goats with water containing acaricide using a piece of cloth or a hand sprayer, every two weeks. 1.5 litres of the mixed acaricide should be mixed with water for each adult goat. Hand gloves should be worn for protection against the acaricide.

Foot rot and foot abscess: The goats should be walked through a foot bat of 5% Copper Sulphate regularly to prevent foot rot and foot abscess. Overgrown and injured hooves should also be trimmed.

Dairy goat farming

The main dairy goat breeds in Kenya include: Alpine, Saanen and Toggenburg. These breeds can be crossed with the Small East African and Galla goats for improved adaptation. The Dairy Goat Breeders Association of Kenya (DGAK promotes best breeding practices and dairy goat production programs among dairy goat producers.

Selection of breeding does

The productivity of a dairy goat flock depends on the quality of does. The following criteria will guide doe selection:-

- High milk production and high fertility rate.
- The doe must be well built and healthy and the legs should be checked for deformities and hooves trimmed.
- Good strong legs are essential for breeding doe.
- Weak bent hind legs are highly heritable factors and females with the condition should not be selected for breeding.
- A female should not be mated unless it is physically fit.
- Emaciated females do not come to heat regularly, they become pregnant and abort or reabsorb the foetus at early stages. Those mated and carry their kid will be unable to rear it satisfactorily.
- It should produce kids every 8-10 months.
- It should produce twins frequently.
- It should produce enough milk to rear the twins and for household consumption
- The udder should be soft to touch with two functional teats, any hardness indicates the female has had a problem e.g. mastitis.
- Long pendulous udder is highly heritable and females with this should not be used for breeding. Big udder is liable to tearing by thorns and kids have difficulty in suckling them and predisposes the doe to mastitis.
- Badly worn teeth indicate old age and females with split, missing or worn out teeth should not be selected for breeding as they are physically unable to browse or graze properly.

Selecting of breeding bucks

The buck must be healthy, strong and should have a well-developed body frame. It must be of productive breed, have normal sexual organs and well developed testicles. The buck must be selected from does that produce a high volume of milk and are prolific.

- Control mating i.e. limit the number of does per male (the recommended ratio is 1male for 35 does)
- The buck must be free of any physical defects e.g. undershot jaws, overshot jaws
- It should have a strong masculine head and neck.
- The buck needs to be noisy, seek out females on heat and mate them.
- A shy and timid buck should be culled.
- Badly worn teeth indicate old age and males with split, missing or worn out teeth should not be selected for breeding as they are physically unable to browse or graze properly.
- Legs should be checked for deformities and hooves trimmed.

Housing

- Provide a house that allows a space of 2 by2m for every goat.
- The floor should be well drained and easy to clean.
- It should protect them from extreme weather eg cold,wind,etc
- The house should allow space for feed trough, water trough, kid pens, feed store and mineral troughs.

Feeds

Goats require five major classes of feeds namely; Energy, Protein, Vitamins, Water and Mineral salts. Goats consume a wide variety of grasses, weeds and small branches of bushes and trees. They can consume leaves, peelings and roots of vegetables, husks of corn, citrus and banana peelings plus other waste plant residues. Goats are ruminants and therefore chew cud and are able to utilise roughage with high fibre content. They produce protein, vitamin B and K in the rumen. Goats are fastidious feeders as a result they are the last animals to die from drought.

Protein sources include:

- Leucaena, Calliandra, Mulberry, Grevellia, Gliricidia, Sesbania, Tithonia, Lantana camara, Siratro, Sweet potato vine, Clitoria tarnatae, Lucerne, Desmodium,
- Most of these herbaceous legumes have anti-nutritional factors (eg tannins and cyanides).
- It is recommended that these should not exceed 25% of the total feed requirement per day. They should be wilted before feeding.
- Groundnut cake, cottonseed cake, sunflower cake can also be good sources of proteins
- Energy sources include
- Rhodes grass, Napier grass, Panicum spp, Cenchrus spp, Sorghum, Bana grass.
- Banana stems and leaves should be fed as a last resort to feed demand.
- Maize, millet, Rice, Wheat, Barley, oats Sorghum others include bean haulms, Sugar cane tops, Sunflower heads.
- Maize germ, maize bran.

Care of Pregnant Doe (She-goat)

- Protein supplements are important during the dry period (non lactating period) since the kids are growing faster at this time.
- Feed should be enriched with high energy feeds (e.g. hay) at least three weeks before kidding to prevent milk fever, in absence of which the doe mobilises its own body stores and prepares for milking.
- Deworm the doe two weeks prior to kidding.
- A goat requires 3% (of its body weight in dry matter approximately 1.5 kg) per day or 5 kg of fresh materials should be availed to the doe per day. The complete meal should comprise of both the protein and energy feed.
- Provide the does with salt lick and at least either half a kilo of dairy meal per day or a mixture of pollard and bran
- Provide adequate clean water all the time.

Care of lactating doe

At the end of the 5th month, the following signs should be observed and actions taken towards birth;

- Reduced feed intake
- Rapid breathing
- Doe will constantly look back unto her sides as if expecting to see young ones.
- Enlarged udder that may or may not discharging colostrums.
- Swollen vulva with thick mucus discharge.
- The hair around the tail and rear should be clipped and fresh beddings (straw or grass) provided.
- The kid is born after short labour, incase of difficulty in kidding consult an expert(Vet doctor)

Feeding lactating doe

- A small quantity of concentrates should be fed to the dry doe in order to build up the body reserves and help in the development of her unborn kid.This is fed in two (2) daily portions
- The amount of concentrates fed should be in proportion to the amount of milk being produced.

Care of kids

- To prevent naval infection, the stump of the umbilical cord should be cleaned and disinfected with iodine, strong salt solution or traditional herbal remedy.
- The new born kid should be placed in a warm area to protect it from strong winds (draft) and cold that may expose it to pneumonia.
- Kids are allowed to suckle the colostrums in the first three days after birth, the colostrum is very important to the health and growth of the kid. Colostrum contains antibodies that protect the new kid against diseases until they are able to protect themselves.
- The kid should be allowed to suckle enough milk so as to have a healthy kid for future breeding stock.
- Fostering is advisable if the mother dies or incase of infection of the udder (mastitis).
- Bottle feeding is an alternative in the absence of the mother.
- Introduce green chop and water after 1 week.
- Kids can be withdrawn from the mother at night so that the doe can be milked in the morning.
- Kids should be weaned at four (4) months. Weaning before this time should be compensated with high protein supplements.

Record keeping

The farmer should keep simple records to support decision making and calculation of profits and losses. Records should include; Birth dates; Birth weights; Sire and dam; Milk records; Treatment records; and Service dates.

2.4.6 SUB-MODULE 6: INDIGENOUS CHICKEN PRODUCTION

Poultry production and in particular indigenous chicken (IC) production plays a significant role in the economic and social life of resource-poor households, contributing to cheap source of animal proteins and cash income. Indigenous chicken are highly adapted to the harsh scavenging conditions, inadequate nutrition and disease and/or parasite challenges. IC presents opportunity for exploitation of their high genetic diversity and are popular among the Kenyan consumers. Low productivity however hinders exploitation of IC in Kenya.

Indigenous chicken (IC) in Kenya are kept for various reasons and apart from food they serve social-cultural, nutritional and economic uses. Despite increasing demand for IC products by local consumers, their low productivity, attributed to high disease incidences, inadequate nutrition, low genetic ability and poor marketing channels, reduce their contribution to rural development.

Origin of indigenous chicken in Kenya

Chicken (Gallus gallus domesticus) are generally considered to have evolved from the jungle fowl (Gallus gallus) inhabiting India, Indo-China, South China, Philippines and Indonesia. They are thought to have been domesticated in South-East Asia from where they were distributed in the course of human migration to all parts of the world.

Population and importance

Kenya has an estimated poultry population of 29 million birds, out of which about 28.7 million (98%) are domestic chicken. Although other poultry species are increasingly becoming important, they are comparatively few (2%) and include ducks, turkey, pigeons, ostriches, guinea fowls and quails. Out of the domestic chicken, about 22 million (77%) are indigenous or crosses with exotic breeds while the rest are commercial broilers and layers (Table 2.56).

TABLE 2.56. INDIGENOUS CHICKEN POPULATIONS AND DISTRIBUTION

Province	Commercial Layers	Commercial Broilers	Indigenous chickens	Others	Total
Nyanza	230,000	99,000	5,683,000	47,000	6,059,000
Rift Valley	437,000	258,000	5,623,000	128,000	6,446,000
Eastern	165,000	113,000	3,865,000	23,000	4,166,000
Western	113,000	18,000	2,644,000	236,000	3,011,000
Central	1,085,000	1,437,000	1,967,000	49,000	4,538,000
Coast	230,000	637,000	1,947,000	94,000	2,908,000
North Eastern	300	200	165,000	0	165,500
Nairobi	188,000	1,607,000	141,000	10,000	1,946,000
Total	2,448,300	4,169,200	22,035,000	587,000	29,239,500

For the last 20 years, IC population has increased by more than 75% while egg and meat products have grown by more than 34% and 79%, respectively (Table 2.57). This increase may be attributed to an increase in the human population and hence a corresponding demand for chicken products as shown by the more than 100% increase in egg and meat production from commercial layers and broilers.

TABLE 2.57. INDIGENOUS CHICKEN POPULATIONS, EGG AND MEAT PRODUCTION TRENDS

Year	Population (million)		Eggs (million)		Meat (Metric tonnes)	
	Indigenous	Hybrids	Indigenous	Hybrids	Indigenous	Hybrids
1984	11.56	3.80	406.58	341.42	6,011.20	3,637.00
1994	17.49	5.10	459.06	521.80	9,094.00	4,553.00
2004	20.77	8.50	545.20	709.47	10,800.20	9,984.30

There is an average of 15 IC per household in over 96% of households in western Kenya and the coastal region where they are important economically, nutritionally, social-culturally and spiritually in both rural and urban areas.

Economic Roles

Despite a lack of defined or measurable indicators for its contribution to the gross domestic product (GDP), the IC sub-sector in Kenya has been recognised as an important economic tool for rural poverty alleviation and households' food and nutrition security. It is estimated that the meat produced by poultry in Kenya is 18,600 metric tonnes (Mts) valued at KSh 3.52 billion. Out of this, IC produced about 11,400Mts (61%) while broilers produced about 6,300Mts (34%) and culls from hybrid layers about 900Mts (5%). While egg production is estimated at 1.22 billion, valued at KSh 9.70 billion with IC producing about 570 million (47%) while exotic layers produced 650 million eggs (53%). The poultry subsector contributes an average of 8% of livestock gross marketed production.

Food Security Roles

A household is food secure when it has access to food needed for a healthy life for all its members (adequate in

terms of quality, quantity, safety and cultural acceptability). Apart from generating income, chicken meat and eggs are cheap and readily available sources of food for the household. Available feedstuffs not consumed by humans are utilised by these birds to produce high-quality and cheap animal protein. Generally, over 18% of the eggs laid and 30% of the household flock are consumed at the household. It has been shown that with only three mature hens, a household is nutritionally secure within one year. In times of droughts and related calamities, chicken eggs become a critical source of animal protein.

Indigenous chicken production systems can be classified according to production objectives into either commercial or subsistence. Based on husbandry practices and levels of inputs and outputs, IC production systems in Kenya have been identified and categorised into free range systems (FRS), semi intensive systems (SIS) and intensive systems (IS). Comparing the profitability of the three production systems, it was found that raising IC under FRS is more profitable than in SIS and IS. However, utilisation of IS should be considered because land availability for practicing FRS is reducing due to the ever increasing human population, and therefore the production systems may shift to IS.

Free Range System

In this system, chickens are reared extensively for various reasons including provision of eggs and meat for household consumption, occasional source of income and various socio-cultural obligations. This system is more common in low human population density rural areas and is based entirely on low input-low output management. Small flocks of less than 30 adult birds per household are kept with minimal care and no supplementation. Free-range feed resources usually include grass, insects, earthworms and various seeds. During cropping seasons, birds are sometimes confined and supplemented with maize, kitchen leftovers and any other available feed resource.

Semi-Intensive System

In this system, chickens are kept in small flocks of between five and 50 birds mainly for consumption and sale. Levels of inputs range from low to medium depending on the commercial value attached to the flock. The birds are left to free range around the homestead or in fenced runs feeding on grass, insects, kitchen wastes, and any other available feed resource. They are provided with some form of housing ranging from simple shelters to proper chicken houses. Health care depends on the commercial value attached to the enterprise. However, water and supplementary feeds are provided. Because input levels are low, production is lower than in IS.

Intensive System

In this system, flocks ranging between 5 and 500 adult birds, depending on the objectives, are fully confined in constructed shelters or runs and provided with commercial or home-made feed rations and health care. The enclosed system protects the birds from thieves and predators. Deep litter and slatted floors are the most common housing systems used. Usually the birds are reared for household consumption, but are mostly for sale. Production of eggs and growth rates are higher while mortalities are low. However, due to high costs of inputs and high levels of management required, this system is rare in rural areas and common in urban and peri-urban areas where households own very limited or no land but are able to provide the required.

Ecotypes and Strains

Indigenous chicken worldwide are reported to be small and multi-coloured birds of no particular breed. In most areas of Kenya, especially those that were covered by the Cockerel Exchange Programme, local chickens are not strictly indigenous as they were crossed with exotic breeds. In those areas, most IC are non-descript crosses of both meat and egg types. However, the effects of the introduction of foreign genes are expected to be low due to natural selection in the harsh free-ranging environment against the non-adapted exotic genotypes. Therefore, use of the term 'indigenous' in this context is still valid. The available IC in Kenya has not been conclusively described. Nevertheless, a few attempts made have reported several distinct morphological variants; some common and others primarily found in certain parts of the country. The major phenotypes include the normal feathered, naked-neck, frizzle-feathered, dwarf, crested-head, feathered shanks and rump-less among others.

In Western and Coastal regions of the country, characterised by warm and humid climatic conditions, as well as in Eastern and Northern parts, characterised by hot and dry climate, the naked-neck, frizzle, dwarf and rump-less genotypes are found kept together with the normal feathered genotypes more than in other areas. This would be expected, as these genotypes are known to be tolerant to high ambient temperatures and other environmental stresses

associated with such areas. In addition, IC in most areas of the regions have major socio-cultural and spiritual roles. Furthermore, along the coast and especially the Lamu islands, a game chicken locally known as Kuchi is common. On the other hand, around Mt. Kenya and the highlands East and West of Rift Valley, characterised by cool and wet climatic conditions, normal feathered, crested, feathered shank and bearded genotypes are kept.

A few IC characterisation attempts, based on morphology and feather colours, indicate wide variations in these features. These phenotypes are an indicator of genetic variability within the chicken population.

Production performance

Some studies have reported production and reproduction performance of IC under backyard, semi-intensive and intensive production systems (Table 4). The various performance parameters are low and highly variable. In the backyard and semi-intensive production systems, age at first egg ranges from 180 to 240 days. However, this has been shown to reduce to 166 days under intensive management.

Males grow faster and are heavier than females, with an average mature body weight of 2.2 and 1.6 kg respectively. The growth rate of IC is similar to that of commercial eggtype hybrids. Hens lay about 45 eggs per year with a range of between 30 and 75 eggs under free range and semi-free range systems. However, some lay up to 120 eggs when supplemented with concentrates. The mean egg weight in all production systems was estimated at 47.4 g with a range of between 36 and 52 g. About three clutches are laid per year with an average of 15 eggs per clutch before incubation. In all the production systems, chicks are produced by natural incubation using broody hens. Fertility and hatchability is usually above 70% but hatching weights are often low, ranging between 25 and 43 g.

MEAN PRODUCTION AND REPRODUCTION PERFORMANCE OF INDIGENOUS CHICKENS.

	Semi-Intensive system	Backyard intensive system	Trait system
Age at first egg (days)	166.0	203	224
No. of clutches/year	4.0	3.0	2.5
No. of eggs/clutch	30	21.2	11.1
Egg weight (g)	42.7	-	-
Fertility (%)	61.8	-	-
Hatchability (%)	74.2	77.0	84
Annual egg production	120	75	40
Chick weight at hatch (g)	32.7	-	-
Chick weight at 8 weeks (g)	438.9	-	-
Body weight at first egg (g)	1630.0	-	-
Mature body weight (g)*	2210^{m}	-	1770^{m}
	1660^{f}		1320^{f}

*m= male; f= female

Diseases and parasites

Observations have shown that diseases and parasites commonly affect IC in Kenya. The most common diseases are Newcastle Disease (NCD), Chronic Respiratory Disease (CRD), fowl pox, coccidiosis, fowl typhoid, salmonellosis, infectious coryza and pullorum. Of these, NCD is the most devastating causing severe losses. This disease has also been reported to be the most important in other developing countries. NCD, CRD and infectious coryza occur mostly during dry seasons between November and March. This is attributed to the dry conditions favouring the spread of the disease-causing microbes and high chicken mobility. Fowl pox, coccidiosis, fowl typhoid and salmonellosis occur mostly during wet seasons. During these wet seasons, chicks are mostly affected by coccidiosis leading to heavy losses. Reports on other important avian diseases that mostly affect commercial hybrids (e.g. Marek, Gumboro, etc) are scarce for Kenya.

Both internal and external parasites are common. External parasites include lice, fleas, ticks and mites, while helminths and coccidia constitute the most important internal parasites. A recent study in Kenya showed that 93.3% of adult IC in semi-arid Kenya were infested with at least one type of helminth. In high rainfall areas helminths infestation of 70.6%, 95.3% and 93.5% for chicks, growers and adult chickens has been reported respectively. It has been observed that coccidian and Ascaridia galli are the most common endo-parasites in the three ecological zones. Although information concerning the prevalence of common external parasites is scarce, lice, fleas, mites and ticks have been reported as the most common, not only in Kenya but also in other developing countries

Herbs are sometimes used to treat sick birds, with the most commonly used herbs being Aloe vera, croton, milkweed and hot pepper. Information on the efficacy and effectiveness of these herbs in the control and treatment of the various diseases is scarce.

Marketing systems

Marketing of live IC and their products is entirely a private sector business. The marketing chain generally involves the producers, itinerant traders, processors and finally the consumers. The marketing process begins with a purchase of an egg or a live bird by a primary collector, direct from the household, or from small locally held weekly markets and ends with a consumer purchasing the products either in their raw form (raw egg or live bird or a piece of raw meat) or processed (cooked egg or a piece of cooked meat). The producer's decision to sell is entirely based on the economics of profits and availability of stocks. Due to lack of formal IC marketing organisations in Kenya, the commercially oriented producers usually have regular primary collectors. Although prices occasionally fluctuate due to market volatility, this marketing system is well developed and stable.

For the subsistence-oriented producers, egg and live chicken marketing is often erratic and unpredictable. The producer's decision to sell is dictated by the household need for cash, that is often critical during times (seasons) of human food scarcity, disease outbreaks and the need to de-stock whenever the population exceeds the household carrying capacity. During food scarcity and disease outbreak circumstances, which occur commonly in a locality, the supply of products, especially live birds, exceed demand by the primary collectors thus leading to depressed prices. For the same demand and supply reasons, the prices are usually stable during normal times and highest during festive seasons. Nevertheless, prices of eggs rarely fluctuate. When buying or selling live birds, prices are also determined by the weight or size and health of the bird. Although IC eggs are smaller and lighter, they fetch higher prices than eggs from commercial exotic birds. However, very small eggs have low market value as they are not preferred by consumers.

The growing consumer preferences and consequent demand for IC products has led to an increase in small and medium scale processing facilities in various parts of the country. In this marketing system, live birds collected via the chain of itinerant traders are slaughtered in private or local authorities slaughter premises, packaged whole or in pieces and sold either directly to consumers or to supermarkets. Birds are manually slaughtered, defeathered, eviscerated, washed, inspected and packaged in plastic bags/containers. Eggs are graded and wrapped in units of two or more using plastic packaging.

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2.4.7 SUB MODULE 7: CAMEL PRODUCTION AND MANAGEMENT

Introduction

- The camel (Camelus dromedarious, the one-humped camel) is an important livestock species uniquely adapted to hot, arid and range environments. It produces milk, meat, wool, hair and hides. It provides long distance transport (a beast of burden), sport riding, and is a draft animal for agriculture.
- In Kenya's rangelands which comprise over 70% of the land surface, camel keeping is increasingly finding its place in the livestock industry.
- The camel is a unique resource adapted and able to utilize the ASAL environment and may be one of the key solutions to the rampant and recurring food crisis in these areas in future.
- It is a more reliable milk provider than other classes of livestock during both dry seasons and drought years. The milk provides about half of the nutrient intake of most camel keepers.
- The average camel produces 5-10 times as much milk as a cow kept under the same climatic conditions due to its prolonged lactation.

Camel Population

The camel population in Kenya is estimated at between 850,000 and 960,000 heads, which represents approximately 6% of the total herbivore biomass in the country, but more than 25% in the arid lands where they are kept.

Adaptation

Adaptation is the suitability of the animal to thrive in the prevailing environmental conditions. Some inherent body parts in a camel that enhance its adaptation include:

- Lips – The upper lips are split and equally divided. This enables them to strip nutritious leaves from the thorny and woody trees.
- Eye lashes - Eyelashes are very long and strong for protection of the orbit. As the camel browses in the bushes, the lashes are meant for protection of the eye from damage or foreign obstruction. The camel has a third eyelid.
- Nostrils - Are rich in hair to protect them from dust and any foreign material
- Ear - Is rich in hairs and is very sensitive

- Nose - Camels have the ability to close and open the nose. When hot, it can open the nose very wide. In the nose there are bones which resemble honey combs. These allow air out and moisture inside.
- Neck - The camel has a long neck. An adult camel can therefore browse to a height of up to 2 metres. This reduces the competition for the feeding area with other animals.
- Legs - Long legs which are meant to cover longer distances
- Raise the animal above the ground
- Keep the animal from the heat on the ground
- Camels rest on their legs when they lie on the ground. Legs have Keratin pads which touch the ground.
- Once on the ground, the animal does not get direct contact with the heat on the ground
- They have large pad-like feet, which enable them to walk over soft sand without sinking. They do not cut up the surface of the soil like the hooves of cattle, sheep and goats and therefore contribute less to erosion.
- Tail –Acts as a ventilator as the animal urinates on the tail and sprinkles over other parts of the body to cool.

How the Camel Adapts to Heat Stress

- Camels have a long narrow body which, through facing either towards or away from the sun:
- Enables them to minimize the surface area exposed to radiation, especially once the sun is past its highest point.
- Around mid–day, when the sun is overhead, fat stored in the hump serves to insulate the parts of the body mostly direct to the sun.
- When facing the sun, the camel opens the nostrils, and the lungs are enlarged.
- The legs are long, and lift their bodies above the ground and away from the hot reflecting surfaces. Cooler air can pass underneath and their large surface to volume ratio permits efficient heat loss.
- Even when lying down, the sterna pad lifts much of the abdomen above the ground so that air can flow beneath.
- Deep body heat is lost through convection by blood circulating through a network of capillaries under the surface of the skin.
- Localization of the fat in the hump minimises its effects as a heat insulator, which might otherwise prevent heat loss from the rest of the body.
- Camels' hair and skin act as good insulators against incoming radiation; surface temperatures may reach 70oC while skin temperatures are 30oC lower.
- The hair of a healthy camel is shiny, which reflects incoming radiation.
- It also may stand erect, allowing air to pass through it and to evaporate moisture from the surface of the skin, cooling it more effectively.
- Cutting the hair of a camel may lead to a 50% increase in water loss.
- Respiration rates of camels remain low even at high temperatures.
- They lose less water through respiration than a cow, as the cow breathes twice as fast.
- Since heavy breathing generates heat they also get less hot.
- Camels have a water conservation mechanism whereby moisture from the lungs condenses on the turbinal bones in the nostrils and is not lost into the atmosphere.

Drinking and Thermolability

- On a weight-for-weight basis, camels drink more water than other forms of livestock when expressed in terms of volume per unit time.
- After cession of rain, camels obtain sufficient moisture from forage and do not need to drink
- Camels once conditioned, can tolerate prolonged periods away from water e.g. during dry season Rendille nomads condition their camels to wait for up to ten weeks after cessation of rain before taking them to the wells
- Camels are thermolabile, meaning that they allow their body temperatures to fluctuate with the ambient

temperature of their surroundings.

- Low air temperatures at night means that camels start the day quite cool but heat up by 6oC or more before cooling mechanisms are triggered.
- Range of body temperature difference is 6oC e.g. in the morning 37 oC can change to 42 oC the body temperature can fluctuate
- Camels do not store water; they conserve it. They store heat during the day and lose it during the night when less energy is required

Camel Distribution in Kenya

- Camels in Kenya were first kept by the Somali people of Northern Kenya where much larger breeds and herds are found. They later spread to the Gabra and Rendille tribesmen of Marsabit and further to Turkana, Samburu and Pokot in recent times.
- They have been more recently introduced in new areas in the southern rangelands. There has been an upsurge of camel keeping in the southern rangelands of Kajiado and Narok counties.
- The threats posed by recent recurrent and more prolonged droughts in ASALs have certainly awakened its inhabitants to pay more attention to camel keeping than ever before.

BREEDS

- The camels in Kenya are normally classified into three classes or breeds: Somali, Rendille/Gabbra, and Turkana. The names used for this classification are primarily based on the ethnic group and distribution of the camels; however, some distinguishing features are apparent.
- Recently, camels have been classified by their use: beef, dairy, dual-purpose and racing.
- Beef camels have well-developed hindquarters, large hump, rigid body, relatively short neck and large head, heavy bones and muscles.
- Dairy camels have a high milk production. They may produce over 2500 kg per year under natural grazing conditions: have well developed udders and milk veins, small hump, less beefy body and relatively big abdomen.
- Dual purpose camels are of medium body size, average milk production (1000-1500kg per year), have a medium size hump and relatively high rate of gain when food is available.
- Racing camels have a small head and ears; alert eyes; a fine and supple neck joined low on the trunk; long and fine shoulders; a very deep chest, well sprung ribs right to the back and terminating not far from the pelvic bone. The legs are straight with fairly close forelegs, straight and well-spaced hind legs, well-muscled quarters, medium sized feet, supple skin, easy and tireless pace.

Classification of Camels in Kenya

- There are not too many ‘’breeds’’ or local types which are distinguished from others by particular characteristics. Size, build, colour and productive traits differ widely within herds but also within tribal, ecological, geographical or political boundaries.
- The camels are mainly classified according to the communities that keep them and they are mainly Somali, Rendille/Gabbra and Turkana. Crossbreeding is common and this makes it very difficult to distinguish separate breeds.

The Somali Breed

The camels are primarily owned by Somali peoples of North-Eastern parts of the country. The breeds are larger than other breeds found in the country. Adult females average 550-600kg while adult males avarage 600-700kg. Birth weights average 30-35kg. Camel owners claim the breed requires more feed than other breeds and prefer browsing although they do graze grass in certain areas in certain seasons. They are often restricted to weekly watering during

dry periods. They have a higher centre of gravity and more at home on flat sandy areas than rocky hills

Camel Nutrition

The nutrition of the camel is fundamental to production of milk, meat, hides and hair. However, the camel is continuously being introduced in non-camel keeping areas hence the need to know more about camel nutrition.

Feeding Habits of the Camel

The camel lives in rangelands where plants struggle to survive. The plants in these harsh conditions have developed one or more of the following characteristics for survival.

- Annuals - which rapidly flower, produce seed and die out?
- Deciduous woody perennials.
- Evergreen woody perennials with cuticular layers to reduce evaporation.
- Succulents.
- Many of the plants have features that protect them against browsers. The camel is a facultative browser preferring leafy, dwarf shrubs if available.

Camels mainly feed on trees (25%), dwarf srubs (50%), herbs (14%) and grasses (11%). From these figures, it is clear that camels feed over a considerable height range - approximately from ground level to 3.5 meters. This gives them an advantage over other livestock. The next best being the goat which can stand on its hind legs and reach up to 2 meters.

In Northern Kenya camels prefer to browse on dwarf shrubs, their favourite plant being Indigofera spinosa, which is a legume occurring extensively in the drier eco-zones and far South in the Tanzanian Rift Valley.

Perennial woody plants comprise three quarters of the camel's diet, the remainder being herbs and annual grasses. Since there is considerable variation in structure and composition of the vegetation in different range types, camels also exhibit differences in their food habits.

Trees in some areas are deciduous, dropping their leaves in dry seasons when they contribute less than 5% of their diet while annual grasses may increase to 33%.

Generally, herbs are used in the few months when they are green, during and following rainy seasons. Annual grasses are eaten in the dry season in the form of standing hay. Perennial grasses however are preferred by cattle but generally avoided by camels since they have a high fibre content, low digestibility and nutritive value. Camels require high mineral intake and prefer halophytic (salt loving) shrubs such as Suaeda monoica, Salsola dendrides and Salvadora persica.

Key browse plants in camel diet

	Species	Type
1	Acacia brevispica	Deciduous tree
2	Acacia mellifera	Deciduous tree
3	A. Nilotica	Deciduous tree
4	Balanites glabra	Evergreen tree
5	Grewia similes	Deciduous shrub
6	Baleria proxima	Dwarf shrub
7	Barleria acanthoides	Dwarf shrub
8	Delosperma remophilum	Dwarf shrub
9	Heliotropium album hispidum	Dwarf shrub
10	Indigofera cliffordiana	Dwarf shrub
11	Indigofera spinosa	Dwarf shrub

Feed Intake by Camels

- Camels can consume 1.67% of their weight daily, goats 2.58%, sheep 2.63% and cattle 3.27%. It is possible to calculate daily dry matter intake (DMI) for each livestock category by multiplying these figures by actual mean live weights.
- This gives the following results: Camels 5.02kg per day, cattle 5.39 kg per day, sheep 0.63kg per day and goats 0.64 kg per day. Apart from cattle, these figures are for animals on a maintenance diet, but not lactating or growing.
- To allow for production the DMI calculations should be increased by 10% for camels and small stock, giving 5.52kg per day for camels; 0.69kg per day for goats and 0.07kg per day for sheep. While cattle DMI remains at 5.39kg per day.
- In some circumstances when camel browse is insufficient or not available, it may be necessary to feed them from external sources. They may not easily accept feeds that are new to them, and therefore they must be induced to accept that which they are not accustomed to.
- Some common feeds that can be availed to camels are:
- Nearly all cut green feed such as maize, millet, sorghum, legumes, grass and lopping from trees and branches are excellent fodder.
- Dry stover, straw, hay, legume stalks, pods, dried leaves of bushes and trees are eaten but need supplementing
- Grains, beans and grams are usually the main supplementary feeds. These should be gristed before feeding

Water Requirements

Camels have remarkable mechanisms for conserving water. Their urine can carry excess salts in very high concentration, thereby losing very little water

Watering Intervals

- One question that is always asked is “How long can a camel go without water? There is no simple answer. With other livestock one can approximate at most 3 to 4 days without serious consequences. With camels there are many factors involved such as:
- The camel itself, if used to frequent drinking, needs to become accustomed to longer periods without water
- The succulence and availability of the feed
- The air temperature
- The amount of hard exertion required of the camel

Camel Milk

- Camels produce milk even during long droughts when other animals cease to produce. It is widely recognized that in absolute terms the camel produces more milk and for a longer period of time than other species maintained in the same environment.
- In East Africa where 60% of the world’s camel population is kept, the consumption of camel milk is not limited just to the pastoral needs, but is also commercialized and sold in urban areas.

Milking Process

- Varies according to the different pastoral groups
- May be milked once or several times in a day
- Most nomadic tribes milk their camels in the early morning before animals are taken to grazing and at night when they return from grazing
- Before milking, the calf is allowed to suckle until the milk is flowing and then the camel can be milked. Without this simulation, the dam cannot be milked
- The milker stands on one leg, puts the milk pot on the upper part of the leg and milks with one or two hands
- Sometimes milking may be done by two persons, each milking two teats
- To prevent calves from suckling while at pasture, it is a usual practice to tie up one or more teats with special strings

Milk Yields and Lactation Length

- It is difficult to estimate the daily milk yield of the camel under pastoral conditions owing to inconsistency of milking frequency. Milk yields also varies with species, breed, stage of lactation, feeding and management conditions
- The length of lactation can vary from 9-18 months
- It mainly depends on the husbandry practices, which are largely determined by the need for milk
- More of milk is required in the dry months than in the wet months when other sources of food are available

Milk Quality

- Camel milk is generally opaque white.
- It has a sweet and sharp taste, but sometimes it is salty
- The taste depends on the type of fodder and availability of drinking water.
- Compared to cow milk camel milk sours very slowly and can be kept longer without refrigeration
- The first milk, the colostrum, is white and slightly diluted as compared with the colostrum of cow milk.
- In Somalia, the colostrum (dambar) is used as a laxative
- Due to its immunological properties colostrum is essential for the new born calves
- However, some pastoral groups consider it unsuitable even for the calves and milk it on the ground
- Camels are known to produce diluted milk in hot weather when water is scarce

The documented and published milk yields for camels in Kenya shows that theyare lower than the range in other countries because

- Camels in Kenya are kept in the marginal areas and receive no feed supplement
- Management levels are low
- There is little or no disease control
- Camels have been kept for subsistence rather than commercial purposes; hence there has been little quality control. Quantity rather than quality of animals are kept.

Major factors that affect camel milk yields include:

- Forage – Quantity and quality
- Watering frequency
- Climate
- Breed
- Milking frequency
- Calf survival and presence of the calf
- Milking method – hand or machine milking
- Speed of milking
- Health status
- Reproductive status

What is clean milk?

- Clean milk can be defined as: “Milk drawn from the udder of healthy animals, collected in a clean dry container and free from extraneous materials like dust, dirt, flies, manure etc.
- Clean milk has a normal composition, possesses a natural milk flavour with low bacterial count, free from toxins and is safe for human consumption. Milk is a high value source of nutrients. If milk is not produced hygienically it can affect the health of many people and can lead to substantial economic losses.
- Camels produce palatable & delicious milk and are an important factor in the capability of people to survive in arid regions.

- Care and management of the animal and its health is therefore the starting point for clean milk production.
- Milk from diseased animals should be kept separate and disposed of safely.
- Animals suffering from any contagious diseases, including mastitis should be separated from the healthy ones.

Milking Practice

- The camels are generally milked in environments that are not ideal for milking. The milk hygiene and quality standards vary greatly depending on management and milking practices.
- Among pastoralists milking vessels are normally made from woven grass, wood fibre or skin. Disinfecting them is often difficult because the vessels are wide mouthed flies, dust and dirt may easily gain access during milking. When good milk is secreted from the udder, it is almost sterile. Contamination occurs at different levels. The employment of hygienic practices at the time of milking is therefore one of the first and most important steps in clean milk production.
- The skin of the udder should be dry and clean from dung and other sources of contamination. The udder is the part of the animal nearest to the milk and should therefore be clean and dry.
- A good milking routine prevents contamination of the milk. The calf should be allowed to suckle at the beginning of the milking to help milk let-down. Gentle milking is an important aspect of good milking practices.
- Potential sources of contamination of milk are dung, water,utensils,soil,feed,the animal and the milker.
- When hand milking the camels, the danger of contamination from the milker is high. The milker should therefore be free from contagious diseases. Nails should be well trimmed; and should wash hands with soap and water before milking, then dry hands with a clean piece of cloth if possible.
- A good milking practice is to milk sick animals last. During milking, foremilk should be examined and abnormal milk should be discarded. The milker should not wipe their hands on the body of the animals or on their own body.
- Dirty milking containers are one of the main sources of infection of milk. It should be rinsed with water. In this way, dust and other contamination will be removed.
- The practice of smoking the vessels used for the storage of milk is a common feature of the various camels herding communities. The treatment has the functions of passing the smoke flavour to the milk or milk product and disinfecting (sterilising) the vessel. Among the plants used in smoking of vessels are Olea Africana, Balanites aegyptiaca, Diplorhynchus condylocarpon, and Combretum spp.
- After cleaning and sanitation, the utensils should be stored properly to prevent contamination from flies, insects, dust, dirt etc. They should be stored in an inverted position off the ground to drain off the water.

Poor Management and Unhygienic Milking Practices:

- A bad milking practice is for example dipping fingers into the milk as a means of lubricating the teats during milking.
- Poor management and unhygienic milking practices prevalent in the traditional husbandry systems include tying the teats with soft barks to prevent the calf from suckling and cauterization of the udder skin.
- The udder is the one of the sites of choice for tick infestation and is usually infested with ticks. A good practice is to remove ticks even when the animal is dry. Tick infestation causes skin lesions that can facilitate bacterial infection.
- Teat canal blockage with dilatation of the gland is a commonly observed problem in dromedaries. The result could be traumatic lesions and lacerations.
- It is therefore cheaper and easier to prevent mastitis by improving hygienic measures than to treat by medication. The cost of the latter includes veterinary fee, cost of medicine (risk of misuse) and loss of milk production.
- Economics of Clean Milk Production: How to deal with needed, but unhygienic milk?
- This is by no means an easy question to answer: Milk is mostly consumed within hours of production and standards for clean milk production reflect the local conditions and how badly milk is needed.
- Boiling of camel milk is rarely practised in the field. With increasing time between milking and consumption, improvement of hygienic measures is required.

- It is best to filter the milk with a clean cloth in order to remove large particles that might have entered the milk. The cloth should be thoroughly washed after use and left to dry in the sun.
- Milk should be stored in clean containers with a lid and kept in a cool and shady place where the danger of contamination is minimal. Milk should be transported in clean vessels.
- Clean milk production should be financially rewarded as an incentive (as an encouragement for producers) for improved hygiene.
- Improved Support Services Necessary for Clean Milk Production in The Future
- An effective and well-trained animal health service and supervision by qualified veterinarians is essential for improving regular healthcare and combating contagious diseases.
- To avoid spoilage, milk collection centres accessible to the producers will be an encouraging initiative. Milk producer's cooperatives could facilitate processing, manufacturing of by- products and marketing to maximise returns to the producer.
- In many camel countries, knowledge of hygiene is often not sufficient. An important support- services regarding clean milk production is education and extension. The aim of this service should be to raise the awareness among the milk producers towards clean milk production and animal health care. These services should be organized at the community level. Women should be given opportunities for training as women mainly do the marketing.

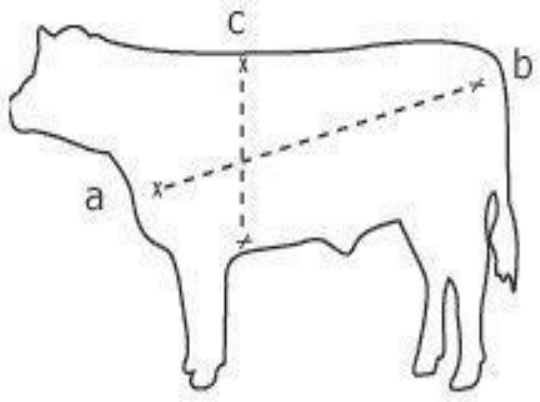
2.4.8 SUB-MODULE 8: BODY WEIGHT AND BODY CONDITIONING SCORING

Many livestock farmers probably do not own livestock weighing scales which are relatively expensive. While disposing of animals, it is important to estimate the weight of the animal as this will determine the price. Weight may also be important during treatment for correct dosage and also amount of feed for supplementation depends on weight of the animal. Several methods have been developed to estimate weight of animals, the most common is the Dalton weight band which calibrates physical measurements into estimated weight directly and has an accuracy of up to 95%. Other methods have also been tried as detailed below

- Measure the circumference of the animal at the heart girth, as shown in "distance C" in the illustration.
- Measure the length of the animal's body, as shown in distance A-B in the illustration.
- Using the measurements from steps 1 and 2, calculate body weight using the formula;
- (Heart Girth2 X Body Length) ÷ 300 = Animal Weight in Pounds (Table 2.58). For example, if a beef cow has a heart girth equal to 70 inches and a body length equal to 78 inches, the calculation would be (70 x 70 x 78) ÷ 300 = 1,274 lbs (577 kgs)

Note 1 lbs = 2.2 kgs

Measuring a dairy heifer.



Measuring beef cattle.

TABLE 2.58. ESTIMATION OF LIVE-WEIGHT OF CATTLE USING CHEST GIRTH MEASUREMENTS

53	23	103	98	152	280
55	25	104	103	154	290
57	27	106	106	156	301
59	29	108	112	158	313
61	31	110	118	160	325
63	33	112	124	162	353
65	35	114	130	164	366
67	37	116	137	166	378
69	39	118	143	168	392
71	41	120	150	170	406
73	43	122	158	172	420
75	45	124	166	174	435
77	47	126	174	176	451
79	49	128	182	178	467
81	51	130	190	180	483
83	55	132	198	182	500
85	59	134	206	184	516
87	63	136	214	186	534
89	67	138	222	188	552
91	71	140	230	190	570
93	75	142	240	192	590
95	79	144	248	194	610
97	83	146	256	196	631
99	87	148	264	198	653
101	92	150	272	200	675

Similarly, Weight Estimates for sheep and Goats have also been developed and are applied as those of cattle with linear measurements of the heart girth giving estimates of weight. The calibrated measurements are shown in Table 2.59.

TABLE 2.59. BODY WEIGHT ESTIMATES FOR SHOATS AS MEASURED AT HEART GIRTH

Hearth girth (cm)	Estimated Body weight (Kg)
27	2
30	3
35	4
40	6
45	10
50	13
55	17
60	22
65	27
69	31
71	33
74	37
76	38
79	42
81	44
85	50
90	59
95	68
100	77
105	86
106	88

Weight Targets for Goats and Sheep

Generally accepted weight, growth rate and age targets are similar worldwide. However mature ewes can range from 50-100kg (average 60kg).

- Birth 3-4 kg
- Weaning (off milk) 16 kg (7-8 weeks)
- Mating 30-35 kg (7 months)
- Kidding 50-55 kg (12-15 months)
- Mature does average 60kg
- Mature bucks 80-100 kg

Body Condition Scores of Livestock

Body condition scoring is a management tool designed to assess body reserves or fat accumulation of an animal. It is a great method for critically examining the nutritional status of the herd. Body condition scoring is a hands-on assessment that uses a numerical rating system based on the feel of the animal to assess body fat accumulation. The measure of body condition is based on a standardised set of visual criteria. A 9-point scale (1- 9) is used to categorize livestock from thin to obese (Figure 2.4). At times a 5-point scale (1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, and 5) is used. Both scales use identical criteria, but assign different numbers to the criteria.

Figure 2.4. Categorization of livestock from thin to obese

Figure 2.5 shows the difference in body fat levels at each of the body condition scores:

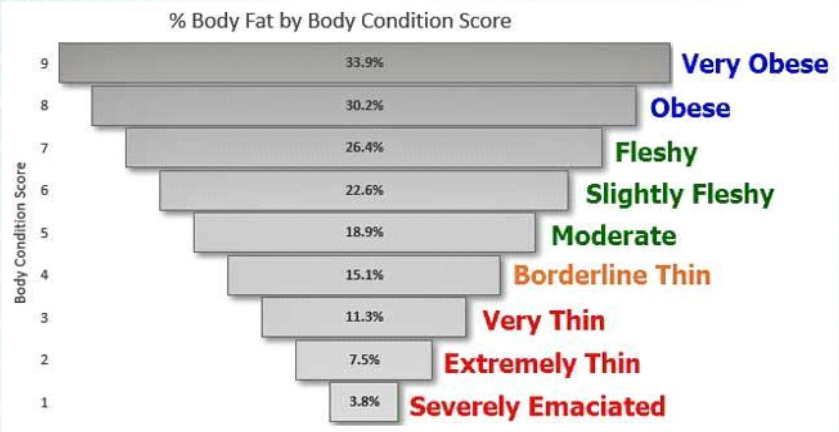


Figure 2.5. Cattle Body Condition Scores vs. Body Fat (%)

The average weight difference between each of the different body condition scores is approximately 45 kg for a medium-framed cow. Thin animals score 1 -3, moderate animals score 4 -6 and fat animals score 7 - 9. The recommended score is moderate.

The animals are scored based on the protrusion of the hooks (tuber coxae) and the pins (tuber ischii) and the depression under the tail head (Figure. 2.6)

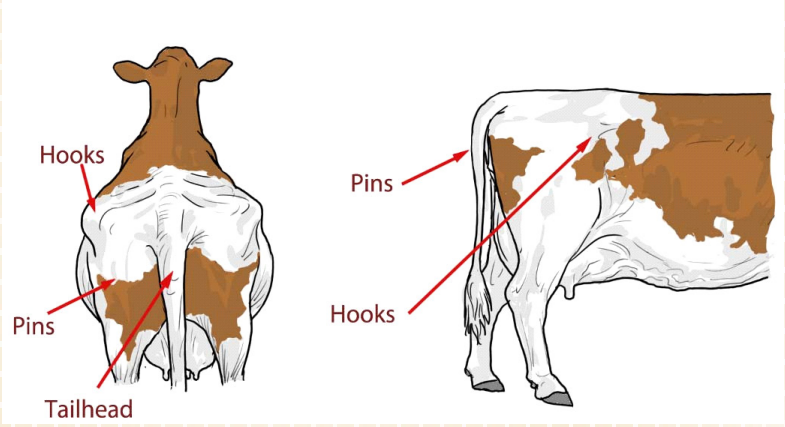


Figure 2.6. Hooks (tuber coxae) and Pins (tuber ischii) Protrusion in cow Illustrations

Body Condition Score 1. Rump Area: Deep cavity around tail head. No fatty tissue felt between pins. Hooks are prominent. Pelvic bone easily felt. Skin is loose.

Body Condition Score 2. Rump Area: Shallow cavity lined with fatty tissue at tail head. Some fatty tissue fell under the pin bone. Pelvis easily felt. High-producing, early lactation cows should score2.

Body Condition Score 3. Rump Area: No visible cavity around tail head. Fatty tissue is easily felt over the whole rump. Skin appears smooth. Pelvis is felt with slight pressure. Pins and hooks not prominent

Body Condition Score 4. Rump Area: Folds of fatty tissue are visible around the tail head. Patches of fat are present around the pin bones. Pelvis is felt only with firm pressure.

Body Condition Score 5. Rump Area: Tail head is buried in fatty tissue. Skin is distended. No part of the pelvis can be felt even with firm pressure. These cows can easily get the condition fat cow syndrome.

Desired Body Condition Scores of Cattle at Critical Times

Time of scoring	Desired score	Reasonable range
CowsbCalving	3.5	3.0-4.0 3.0-4.0
Peak Milk	2.0	1.5-2.0
Mid-lactation	2.5	2.0-2.5
Dry off	3.5	3.0-3.5

Condition Score Targets for Sheep and Goats

If farmers can accurately assess body condition, they can plan in order to achieve the desired body condition before kidding. This ensures that feed is used efficiently and that optimum production per doe is achieved. Some practical and economic factors will affect management but the underlying principle is that the higher the condition score at kidding, the greater the body reserves available for production in early lactation.

A doe in good condition (score 5-6) is more likely to get a kid than a doe in poor condition, and is more likely to have twins. She is more likely to have a quick birth, a healthy kid and good milk production. Improving one score in the score range 3-6 will give an extra 35 litres per doe over a lactation for dairy goats, and increase protein and fat levels by about 0.2% during the first five weeks of lactation. Improving a doe's or ewe condition score by one is equivalent to increasing her live weight by 6kg.

Main Indicators

- Short ribs: The projections sideways below the backbone
- Loin: The muscle area between ridge of backbone and short ribs

Base of tail: sometimes the tail may be raised especially pre and post kidding, giving a misleading impression of poor condition. The backbone on the rump may also be raised, an individual conformation factor not a condition score issue.

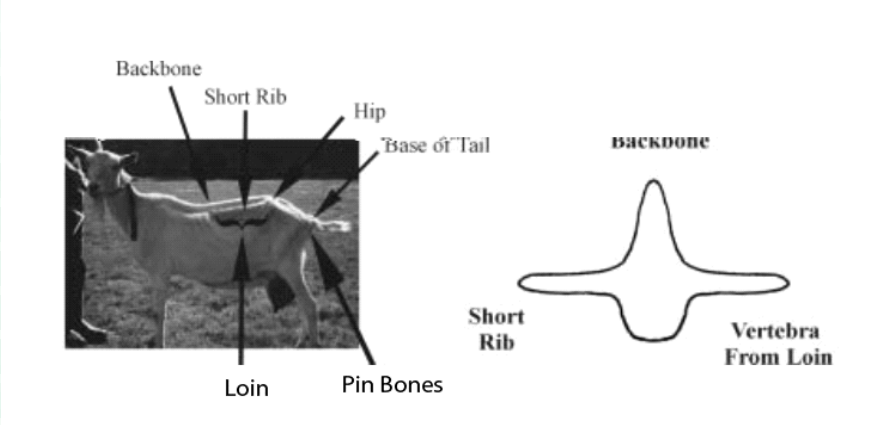


Figure 2.7. Body condition Indicators

Goat and sheep body condition scoring

Score 1	Score 2	Score 3	Score 4
Minimal flesh over skeleton Backbone: A sharp prominent ridge, vertebrae clearly felt/ visible along its entire length. Short ribs: very sharp, fingers fit easily underneath	Ribs: easily felt / visible. Backbone: very prominent ridge. Short ribs: sharp, easily felt underneath. Loin: slight muscle, deeply concave. Hips: very prominent. Pins: prominent. Base of tail: deep hollows	Backbone: a prominent ridge. Short ribs: prominent, can feel under. Loin: moderately concave. Hips: prominent. Pins: slight cover. Base of tail: small hollows	Backbone: slight cover. Short ribs: smooth edges. Loin: slightly concave. Hips: slight cover. Pins: Light cover. Base of tail: slightly sunken

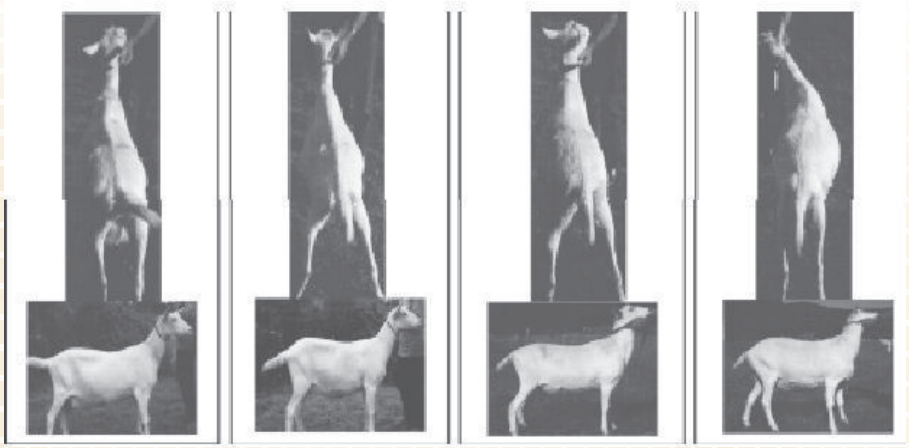


Figure 2.8. Illustrations of Body Conditions for Shoats

Score 5	Score 6	Score 7	Score 8
Backbone: Light cover Short ribs: Light cover Loin: flat between 3 points. Hips: light cover. Pin: rounded. Base of tail: almost filled out.	Back bone: smooth cover. Short ribs: hard to feel. Loin: slightly rounded Pins: well rounded. Base of tail: filled out	Backbone: can only just be felt. Short ribs: hard to feel. Loin: well rounded. Rump: slightly rounded. Hips: well covered. Pins: well covered. Base of tail: some fat rolls across the rump above the tail.	Backbone: can only just be felt. Short ribs: can't be felt. Loin: very well rounded. Rump: rounded. Hips: not obvious. Pins: not obvious. Base of tail: fat roll across rump above tail.

Score Targets are based for Shoats

- Growing kids 5-6
- Joining 5-6
- Kidding 6
- Milking 3-5
- Bucks (mating start) 7

An average size doe/ewe will need to gain approximately 6 kg in order to increase one condition score.

2.4.9 SUB-MODULE 9: DESTOCKING AND RESTOCKING

Introduction

During calamities particularly drought in pastoral areas a substantial number of livestock perish thereby communities losing some or all of their animals. Recovery of herds after drought can take many years, during which time households remain dependent on local support mechanisms or external aid. Alternatively, after the calamity, restocking programmes may assist some households but are far more expensive than preserving key livestock assets during a drought. At a time when market prices for livestock can be falling, destocking aims to convert non-essential livestock into resources - mainly cash or meat - which people can use during the drought.

Destocking has been carried out in Kenya since the 1980s when UNICEF initiated destocking operations to provide relief meat to feeding camps in the ASAL areas of the country. Since then, a number of agencies, mainly NGOs, have carried out destocking in pastoral areas for slaughter and meat distribution. Such operations have usually been on

smallscale, localised, and often implemented in an *Ad hoc* manner. More importantly, these interventions have nearly always started late in the drought cycle when substantial livestock mortality has already occurred, or when livestock had lost considerable body weight resulting in a sharp decline in prices. The value of animals salvaged in this way has generally been minimal although some useful lessons have been learnt that have the potential to support the design of more effective destocking programmes.

More recently, 'commercial destocking' (sometimes called 'accelerated livestock off-take') has been used in pastoral areas of Kenya, with government and NGOs facilitating linkages between livestock traders and drought-affected communities. There are two main approaches to de- stocking that can be used in Kenya, commercial destocking and slaughter destocking

Commercial destocking involves the engagement of livestock traders to boost livestock off-take from a drought-affected area so that they can be fattened and sold through terminal markets. This type of destocking provides pastoralists with cash, which they can use to buy other commodities and services they need, including items to protect their remaining livestock. This type of destocking should take place as soon as possible, at the onset of drought, before the livestock loose body condition and value.

Slaughter destocking programmes are based on the purchase of livestock by an aid agency, followed by immediate, local slaughter and the distribution of meat in either a wet or dry form. This type of destocking takes place later in a drought period, at a time when livestock traders are no longer purchasing livestock which are in poor body condition and immense loss of body weight.

One way to view destocking is as a cash-transfer mechanism. Commercial destocking is preferred because it results in pastoralists selling animals earlier in the drought period and receiving a higher price per animal. Even when livestock prices are falling and grain prices are rising during drought, the sale of only a few animals can provide a pastoral household with sufficient grain to sustain it for weeks or even months.

Supplementary feeding - the adequacy of feed resources for the animals that are retained after destocking needs to be considered and provision made for supplementary feeding as necessary. Ideally, if de-stocking is conducted early enough, private suppliers can provide at least some of the required feed.

Veterinary support - destocking can reduce the risk of disease transmission by reducing animal density and the removal of sick animals. However, adequate veterinary care still needs to be provided for remaining animals. Again, if conducted early during the drought, veterinary care can be provided by private veterinary workers.

Water supply - adequate water for the needs of remaining animals needs to be provided as well as that required to ensure hygienic practices during slaughter destocking operations.

In addition to these services, agencies need to be aware of food aid distribution and safety net provisions in a given area and where possible, integrate livestock interventions with these other types of assistance.

Although destocking is sometimes justified in terms of limiting pressure on grazing resources, in Kenya to date there is limited evidence to show the environmental impact of these interventions. It is possible that large-scale commercial destocking could have positive environmental impacts, and this is an area which requires evaluation in future.

Advantages and disadvantages of destocking

- Allows purchase of livestock which otherwise would have died, thereby providing cash to households (commercial destocking), or, cash and meat to households (slaughter destocking); meat is a use-
- Full dietary supplement particularly for children and pregnant or nursing women.

- Livestock prices can be rapidly eroded in emergency situations. Hence, commercial destocking initiatives have a narrow window of opportunity during which implementation is financially viable.

• The cash derived from destocking - especially commercial destocking - is often used to support local markets and services, and to protect remaining livestock. This reduces the need for other interventions and helps to maintain the local markets and services needed for recovery.	• The interest of commercial traders will partly depend on factors such as the final demand for meat or live animals in terminal domestic or export markets, and the capacity of holding grounds or feedlots. Commercial destocking is therefore highly dependent on the state of live-stock markets during normal periods.
• Commercial destocking can be very cost-effective as a large part of the financial burden is borne by participating traders.	• Some traders may have insufficient capital to buy large numbers of animals. The provision of rapid loans during drought is currently problematic.
• Slaughter destocking can augment other sources of food aid by redistributing meat within affected communities.	• Some pastoral communities are reluctant to consume meat from drought-stricken animals for cultural reasons. Careful dialogue with communities is needed to change attitudes.
• If a substantial proportion of the livestock population in a given area is destocked, pressure on natural resources may be reduced.	• Commercial destocking by private traders partly depends on good infrastructure, especially roads, to access more remote communities.
• As part of an integrated emergency response, judicious destocking can be used to enhance the viability of other interventions aimed at preserving herds (e.g. supplementary feeding).	Removal of livestock from a community is a drastic measure. Other interventions (e.g. relocation or supplementary feeding) will allow more rapid herd reconstitution during the recovery phase.
• If a longer term view is taken, destocking offers the opportunity to cull poorer quality or chronically diseased stock. These may be replaced with better animals during the recovery phase.	• Many NGOs are not used to working with traders during emergencies, or donors may not allow NGO support to traders.

Guidance on the Timing of Commercial Destocking

In Kenya various sources of early warning information are available to indicate that commercial destocking is required. In areas where early warning systems are not operational, field-level assessments by experienced practitioners can be used as early warning reports. In the case of early warning systems based on remote sensing, field-level verification of information is required.

Using the drought cycle management model, commercial destocking should take place in the alert and alarm stages of a drought. The indicators which inform a decision to support commercial destocking include:

Deviations in water availability and pasture production - rainfall failure or reductions in precipitation in the short and long seasons in any given year will generally lead to reduced pasture and standing water. In some cases, this could be a localised problem that can be resolved by indigenous responses.

Periodically however, drought may affect the entire ecosystem and extend to populations in neighbouring countries. The severity and extent of disruption in biomass availability is monitored by the online Livestock Early Warning System.

Consideration during Destocking

Some specific issues which need to be considered during the rapid analysis and subsequent dialogue with traders include:

- The location and size of the drought-affected area(s), and therefore, an approximate estimation of types and numbers of livestock which might be available for sale
- The general body condition of different species and types of livestock, and their market value; while some traders may prefer to buy only animals in relatively good body condition, other traders may buy thin animals with a view to fattening them
- The demand for specific types of livestock and meat in various domestic and international markets
- The capacity of abattoirs, feedlots and holding grounds, and government commitment to making land available as temporary holding grounds if necessary

- The location of the drought-affected area(s) with respect to main roads, accessibility to communities who may sell livestock, and an understanding of the additional transaction costs required to reach more remote areas
- The capacity of local government and NGO actors to work with communities to create temporary markets, and to explain the commercial destocking approach to communities
- The commitment of the government to relax certain taxation issues or other bureaucratic procedures, thereby enabling rapid purchase and transport of livestock by traders
- Options for combining off-take of livestock with the provision of livestock feed to remaining animals, using the same vehicles.

Guidance on the design and implementation of commercial destocking

Most types of livestock interventions in pastoral areas during drought are very much under the control of government agencies and NGOs, and these actors can work with communities to design specific aspects of the intervention in question. In contrast, commercial destocking is largely shaped by market factors and the need for private traders to make a reasonable profit from their activities and minimise risks to their investment.

Design and implementation issues which can be influenced and facilitated by government and NGOs include:

Communication and liaison with communities - to explain the commercial destocking approach and to introduce livestock traders to communities e.g. through field visits arranged for the traders.

Identification of sellers - discussion with communities to agree which households should sell animals. The sale of only a small number of animals can enable a household to acquire sufficient grain to meet its nutritional energy needs for many weeks, or even months. In terms of relief assistance, it is therefore preferable to support an approach whereby many households have the opportunity to sell small numbers of livestock, rather than a few households selling many livestock.

Support Measures - through a strong, central coordination body government and NGO actors can help to ensure that various support measures are in place to facilitate commercial destocking. These measures include:

Health inspection of purchased livestock - by government veterinary public health officers.

Temporary holding grounds – the coordination body should support implementing agencies by liaising with regional, zonal authorities to secure temporary holding grounds where traders can assemble purchased animals until they are fit for transportation. Traders may also require additional land close to feedlot centres in order to accommodate increasing numbers of animals.

Provision of water and feed - the national coordinating body should coordinate the provision of feed to livestock purchased by traders on a full cost recovery basis. These animals should also be given access to existing water points in the operational area.

Veterinary services - liaising with the Department of Veterinary Services will ensure that recommended vaccines and drugs can be supplied for livestock assembled by traders by veterinary professionals.

Fuel availability - the national coordinating body should take measures to ensure the availability of fuel along major destocking routes.

Security - coordination with local authorities will be needed to make sure that accessible sites are safe and secure enough for commercial destocking.

Taxation - the national coordinating body should negotiate with federal and regional customs offices to exempt livestock traders from paying transit taxes when moving livestock across regions in times of emergency.

Transport - the use of options, such as government owned vehicles, should be explored to alleviate transport shortages for moving livestock. Support should also be provided by the Road Transport Authority in order to minimise unnecessary delays.

Control measures - a number of control measures need to be implemented to minimise the likelihood of unscrupulous individuals capitalising on the situation for personal gains. These measures are particularly important in the case of transport subsidies and as such subsidies are not a preferred option for destocking, they will not be commonly applied. In the event that transport subsidies are used, purchased livestock need to be marked

(tagged or tattooed) and local officials need to ensure that their departures (date, time, vehicle particulars and operators etc.) are properly documented. Inspection officers receiving animals at fattening centres can then verify that the livestock have been properly transported by checking against the original documents. In general, payments should only be made after ensuring that purchased stocks have arrived at the fattening centre.

Selling arrangements - working with communities and traders to agree on issues such as the location and timing of purchase areas and temporary markets. Agencies need to identify target locations for destocking programmes based on both need and feasibility. Access problems can be a major issue limiting the geographical coverage of commercial destocking. Households wishing to sell livestock may be scattered within villages, and villages may be some distance from each other. Therefore, commercial destocking may tend to benefit people in villages that are relatively close to major roads at the expense of people living in more remote areas. To some extent, this problem may be addressed by adopting a rotational operation in which isolated communities are reached by specifying fixed, temporary market days for different locations. Purchase sites and timing of markets should be determined in consultation with local communities. They should generally be existing villages or temporary settlements to avoid the need for lengthy trekking of weakened animals.

Monitoring arrangements - so that livestock purchases by type and price can be recorded and assigned to specific households. This is a key role for NGO or government actors, and can greatly assist evaluation and assessment of the destocking at a later stage.

Aspects of commercial destocking may be heavily influenced, if not determined by the traders inclued:

Types of livestock for purchase - the species, age and sex of livestock to be purchased, and the preferred body condition. Traders know the best end-markets for purchased livestock and will select animals accordingly. As a general rule, young adult or adult male animals in good body condition will be bought, although in some situations traders will also buy very thin livestock knowing these animals can be fattened and sold at a later date. To some extent, trader preferences will match pastoralist's preferences, because pastoralists will tend to retain adult breeding females to assist herd recovery after drought.

The price of livestock - the prime motivation for traders is profit. Traders realise this profit as a result of low prevailing purchase prices for drought-affected animals. When animals are thin, a rapid weight gain is possible when they are returned to an adequate plane of nutrition.

A significant element of profit maximisation for traders is the minimising of costs including road access, provision of water, feed and security. As a result, traders will opt to purchase animals that are in better condition (for the price) and closer to roads.

Slaughter Destocking

Slaughter destocking is a less preferred option compared with commercial destocking, because it usually takes place when livestock traders are no longer willing or able to buy livestock from drought-affected areas. Therefore, slaughter destocking occurs during the emergency phase of a drought when livestock condition is very poor and unless purchased and slaughtered, large numbers of animals are likely to die without any benefit (or only very minor benefit) to their owners. Slaughter destocking usually requires the use of funds from aid agencies and therefore is limited in terms of the numbers of animals which can be purchased.

Compared to commercial destocking, there is much more experience in Kenya with slaughter destocking and in part, this is because slaughter destocking usually takes place later in a drought.

Guidance on the Timing of Slaughter Destocking

Although slaughter destocking is less preferred to commercial destocking, it is still an intervention which can offer a rapid way of reducing the burden of livestock upon peoples' livelihoods under the extreme conditions of an emergency situation. At the same time, it can deliver tangible benefits to affected households by providing meat or cash, and can also provide short-term employment for a limited number of community members.

The decision to conduct slaughter destocking or not should be informed largely by information on the stage of a drought and the behaviour of livestock traders. Therefore, slaughter destocking should take place when:

A drought has entered the emergency stage in terms of drought cycle management

Traders are no longer willing to buy livestock due to factors such as the poor body condition of animals (and therefore, high mortality during transportation) or the inaccessibility of communities due to poor roads or other reasons. At this time, sharp drops in livestock prices resulting from loss of condition are evident.

It can be noted that some areas may be viewed by traders as inaccessible during the alert or alarm stages of a drought and in these situations, slaughter destocking could be considered before the emergency stage.

Guidance on the Design and Implementation of Slaughter Destocking

In slaughter destocking, drought-affected livestock are purchased by an aid organisation. Purchased livestock are then slaughtered locally and either fresh or dried meat is distributed to targeted households. Within communities there are various distinct groups of actors and beneficiaries who need to be recognised and involved in the intervention. These community-level actors and beneficiaries are:

Local or traditional leaders or decision-making groups

- Livestock sellers
- Meat handlers
- Meat recipients

It can be useful to work with local or traditional leaders to establish a 'meat relief committee' (MRC) or similar local body. An MRC can be of considerable value for helping to identify beneficiaries, overseeing the operation and ensuring that distributions reach the intended recipients. The formation of MRCs can also help to distribute power that might otherwise be monopolised by other 'Food Relief Committees' and share some of the general responsibilities of the implementing agency. Other specific roles for an MRC include:

- Assigning responsibilities to different community groups
- Assisting with the identification of beneficiaries
- Organising groups for slaughtering and meat distribution
- Distributing live animals for slaughter
- Supervising slaughter, meat distribution and the collection of hides and skins from the beneficiary groups for the intended purpose, if needed.

Slaughter Destocking: Key Design Issues

Ideally, a participatory approach should be used during all stages of design and implementation with frequent use of open meetings in communities in which people can hear and contribute to discussion.

Selection of livestock sellers - this should be based on clear, commonly understood criteria for identifying the most vulnerable households. Wealth ranking or similar techniques can assist this process, and the actual selection method should be sensitive to local culture and avoid compromising the dignity of the families involved. As the extent of livestock purchases is likely to be finite and defined by budgetary considerations, it is likely that not all drought-affected animals available for purchase can actually be purchased within a given community. Therefore, decisions will need to be made on who is eligible to sell animals and receive cash payments. Ideally, livestock sellers in a slaughter destocking intervention should comprise as many of the most vulnerable households as possible, with due emphasis on female- headed households.

Types, number and prices of livestock to be sold - depending on the available budget, an agency will need to work with communities to carefully define the number and type of livestock which can be purchased from each household. The greater the number of animals purchased from each household and the higher the price per animal, the fewer the number of households which can be targeted. Again, discussion and decisions on these issues can take place in open meetings so that it becomes commonly known how decisions were reached. The amount of cash to be received by each household from livestock sales during slaughter destocking, needs to be sufficient to make a substantial contribution to household income during the anticipated drought period. If too little cash is received, households will continue to rely heavily on other forms of assistance, whereas if too much cash is received, fewer households will be reached.

As a general rule young, reproductive female animals should be excluded from slaughter destocking programmes as they will form the foundation stock for herd re-establishment during the recovery phase. Old male animals, surplus

young males, non-reproductive females and ailing stock (excluding any that may pose a disease risk to the people who eventually consume them) may be used for slaughter destocking. Often it will be sound practice for less drought tolerant species (cattle and sheep) to make up the bulk of the animals to be destocked.

Excessive differences in the purchase price of animals for slaughter destocking within and between neighbouring geographical areas can lead to resentment and harassment of staff working for lower paying agencies. Strong coordination within and between areas can help to overcome these problems. The coordinating body should assess the prevailing livestock market prices in various localities to determine a uniform purchase price for each type of species, which should be adhered to by all implementing agencies in the same geographical area.

Types of meat for distribution - dried meat processing can be a complex and costly process that involves skinning, cutting, slicing, salting, cooking, drying, storing and guarding the meat. It is important that proper hygiene procedures are applied and that plenty of water is available for processing and cleaning. Local rituals, beliefs and taboos relating to animal slaughter may need to be taken into account with guidance from local NGOs or other agencies with long-term development experience in the particular area. Fresh meat distribution is a far less complex process once purchasing and distribution systems have been put in place, but has the disadvantage that fresh meat is more perishable than dried meat. Overall, fresh meat distribution is relatively simple and cheaper than dried meat distribution.

Amount of meat to be distributed - in order to represent a useful dietary supplement to vulnerable individuals, the amount of meat distributed should be sufficient to make a good contribution to daily protein requirements, for a sufficient number of days (Table 2.60).

TABLE 2.60. FRESH AND DRIED MEAT AS PER THE APPOXIMATE BODY WEIGHT (KG)

Livestock species and type	If drought- stricken	Of fresh meat in carcass	Of dried meat from 1 animal
Camel adult male	250–300	88–105	22–26
Cattle, adult male	120–150	45–60	9–12
Sheep, adult male	10	5–6	1
Goat, adult male	10	5–6	1

Selection of meat recipients - the people selected to receive meat should include the most vulnerable families in the community and particularly those with many children, pregnant or nursing mothers, widows and the aged. For cultural reasons, it is likely that targeted households will share the meat with non-targeted households in pastoral and agro-pastoral settings. If this is the case and sufficient quantities of meat are available, distributing meat more widely in the community will help to avoid resentment. Distribution may also include community-level facilities such as schools, hospitals or prisons that would otherwise go without direct supplies of food.

Hygienic slaughter and meat distribution - the capacity for the programme to implement hygienic slaughter and meat preparation practices needs to be considered at the design stage. Slaughter destocking should include pre and post mortem inspection by livestock or public health officers. Environmental contamination can be reduced by slaughtering on concrete slabs with effective drainage systems or if such facilities are not available, by changing the slaughter sites as frequently as possible. Allowing beneficiary families to do their own slaughtering and distribution of fresh meat can reduce risks of disease. Proper disposal of inedible offal, blood and other wastes and hygienic meat preparation practices can be encouraged by providing rapid, basic training to community members. Locally-acceptable practices relating to the slaughter and skinning of animals and the preparation of dried meat must be observed and understood. These may be based on religious or cultural grounds, or in some cases may simply be associated with taste preferences. For example, in some areas meat may be boiled first before drying while in other areas meat may be salted and dried, or, not only salted but also sprinkled with pepper before drying.

Slaughter Destocking: Key Steps In Implementation

Procurement - the programme may purchase animals directly from owners or contract-out the procurement process to community-based groups such as women's groups or cooperatives. As well as reducing the burden on the implementing agency, this approach can provide financial benefits for the groups involved. It may also help to increase the geographical coverage of the initiative as contractors can be engaged at each of the locations where the programme will operate. Transparency in pricing is important and community members should be made aware of the fixed prices that they will receive for their livestock and the prices at which the animals will be sold on to the

implementing agency.

Slaughtering - slaughter and distribution operations need to be scheduled in order to minimise wastage. In the case of fresh meat distributions the meat produced at each slaughtering should not exceed the quantity that beneficiaries can consume within a few days. Depending on the type of meat distribution and the species being killed, slaughtering may take place on a bi-weekly, weekly or fortnightly basis in order to ensure continuity of supply to beneficiaries for the duration of the operation. Salt may be distributed along with fresh meat.

Fresh meat distribution - needs to be frequent and regular, preferably once each week. The consent of communities should be sought in advance to ensure that they will be able to slaughter and distribute fresh meat amongst themselves, on this basis, with minimal external supervision.

Dried meat processing and distribution - dried meat operations need more equipment and other materials compared with fresh meat handling. A list of basic materials required, and requirements should be assessed at the planning stage. Some equipment may be available locally but other materials may need to be brought in from commercial centres close to the operational area. Water availability should also be considered as it is crucial for dried meat processing. Dried meat may be distributed as a component of a relief food ration (assuming that food aid is being provided in the area) or on its own. Integration with existing food aid requires weighing and packing of meat so that it contributes to the delivery of recommended dietary allowances for protein. Otherwise, distribution may take place on an ad hoc basis as deemed necessary by local MRCs and other community representatives; MRCs should be involved in deciding the most appropriate approach at each location.

Selection of meat handlers and incentives - ideally, families that will receive meat from the programme should be organised into groups that will carry out slaughter and distribution amongst themselves in order to minimise costs to the implementing agency and maximise the number of households which can be restocked. In some situations, agencies may also choose to employ some local people temporarily. For example, youths might be employed for slaughtering, flaying and guarding the meat. Vulnerable female-headed households may be prioritised for employment in preparation of dried meat as they usually possess the necessary skills already.

Coordination of meat distribution and distribution of other types of food - where possible, meat distribution should be synchronised with relief food distribution for maximum impact.

Pre and post mortem inspection arrangements – ante and post mortem inspection should be con- ducted to minimise the risk of disease transmission to humans through meat consumption or contact with animals. The programme should seek the services of animal or public health specialists working in close proximity to the operational area.

Disposal of hides and skins - all fresh hides and skins should be dried properly after slaughter under the supervision of the MRC. Ideally, this should be carried out on wooden frames, indoors at designated locations. Income generated from the sale of hides and skins can be used to pay the wages of community members involved in the operation or to support more disadvantaged people. Community members involved in slaughtering should be properly trained in techniques for flaying and drying hides and skin

Livestock restocking

A restocking programme aims to rebuild a productive livestock holding for pastoralist households that have lost most of their animals as a result of an emergency, and have no means of their own to recover. Restocking may be appropriate after various types of disasters, such as drought, flood or conflict. Almost by definition, restocking takes place after an emergency although in the case of a slow onset emergency, some degree of forward planning may be possible. Relative to most other types of interventions, restocking is an expensive option because it requires the replacement of livestock. It follows that in most restocking projects the number of recipient households is very much determined by project budget.

In agro-pastoral communities, households are less dependent on livestock than pastoralists and so relatively fewer animals are provided. These communities may also be less mobile than pastoralists, thereby making monitoring of households easier. For pastoralists, restocking is more difficult due to the larger number of animals that will be required to establish a viable herd size and the mobile nature of the affected communities which makes delivery of animals and monitoring the success of the initiative complex.

Pastoralists use various indigenous strategies during drought to try to avoid losses of livestock, especially breeding

females. These strategies include:

- Extending the movement of herds and flocks beyond commonly used areas in order to locate better pastures at more distant locations
- Undertaking supplementary income generating activities locally
- Out-migration of some household members to earn additional income and to reduce demands on the household asset base
- Modifying herd structures: specifically replacing large stock (cattle, camels) with small stock (sheep, goats) that will reproduce rapidly in order to re-establish viable herd sizes
- Gifts or loans from less severely affected clan households to poorer households, as practised by the Boran, Somali communities and other pastoralists.

Externally-supported restocking is needed when these traditional mechanisms break down. Programmes may be implemented with the aim of rehabilitating herds or flocks in the short-term or as long-term development projects, and various types of repayment and credit systems can be used. External interventions should always attempt to complement and build upon indigenous approaches rather than to replace them.

Restocking programmes should not be carried out in isolation from other rehabilitation efforts directed at both the human and livestock populations of the affected areas. Other interventions are needed because it usually takes several months or longer for herds to become sufficiently productive to make a substantial contribution to livelihoods. For example, a new herd of breeding goats will need to deliver new offspring and these offspring will have to become young adults before sales are possible. Therefore, restocked households may require food aid, safety net support, basic household items and veterinary care. These diverse inputs require good coordination between agencies.

Advantages and disadvantages of restocking

Advantages	Disadvantages
Can allow rebuilding of the asset base of affected communities in a manner that is compatible with traditional means of securing livelihoods.	Restocking is time-consuming and labour- intensive compared with other post-emergency interventions.
Restocked herds should be sustainable in the long-term without the need for further intervention – at least in the absence of further emergencies arising.	Planning can be complex and, particularly in drought situations, future threats due to unpredictable rainfall can threaten long-term viability.
Other development interventions that might offer similar long-term benefits – such as the establishment of irrigation agriculture – are too costly, high maintenance and unacceptable to potential beneficiaries.	Costs, particularly initial costs, are very high per household. It is important that financial provisions are adequate to ensure that the programme can be implemented equitably in affected areas.
After severe droughts, surplus grazing is available. Restocking allows this to be used effectively before its quality declines and the risk of bush encroachment develops.	The most-severely affected families are often in remote areas that are difficult to access. The costs of restocking these areas may be unacceptably high.
Can help to reduce dependency on feeding camps and food aid more rapidly.	The following threats should be avoidable if a restocking programme is planned effectively: There is a risk of overgrazing if the carrying capacity of grazing areas is not properly assessed; The species composition of herds may change limiting their contribution to the traditional livelihoods' asset base; Restocking efforts can erode traditional coping mechanisms if not properly built upon and complementing indigenous approaches.
Helps to restore the personal dignity of affected individuals by supporting a rapid return to traditional lifestyles.	

Needs Assessment and Planning

As restocking with pastoralists in Kenya has usually been used after drought, there is often more time available for assessment and analysis relative to interventions used earlier on in the drought. Agencies should take advantage of this time to conduct proper assessments to inform the need, feasibility and design of restocking. The following key questions need to be considered when restocking interventions are under consideration and a supporting checklist is provided below.

Local Acceptability of Restocking

For many pastoralist households after drought, restocking is probably the most acceptable route back to a traditional way of life. Other interventions may involve a major departure from pastoralism resulting in the loss of the skills and knowledge needed for the successful management of livestock in fragile environments. These alternative interventions include more settled agricultural production, but this livelihood option is also highly dependent on rainfall. Although alternative livelihood strategies are now attracting increasing attention from aid organizations, to date experiences have been small-scale and where benefits have been measured, these have reached only a small proportion of a population.

In summary, it seems that restocking will be the preferred recovery option for some pastoralist households, while others may prefer to move out of the pastoral sector and receive other kinds of support.

The Cost of Restocking

The major costs to be taken into account when considering a restocking programme include:

- Operational costs of managing the scheme including transport and accommodation of personnel
- Cost of procuring the animals
- Costs of veterinary inputs
- Cost of food aid
- Overhead costs, including maintaining holding facilities, animal losses, administration etc.
- Monitoring and impact assessment costs
- From previous project evaluation, the success of restocking programmes will depend on how many households to restock, and how many animals to be provided.
- In terms of overall cost, restocking generally compares favourably with alternative development initiatives although initial expenditure may be considerably higher because of livestock purchases. However, these costs need to be set against the potentially self-sustaining nature of restocking programmes in the longer term and their capacity to build household wealth. Even for agencies which have used restocking extensively, there can be tension between administrative staff or programme managers who wish to see a high number of households with fewer animals for a given budget, and technical staff who have better understanding of viable herd size and traditional restocking strategies. It is possible that restocking with sub-optimal numbers of animals contributes to low success rates and repeated bouts of restocking almost on a yearly basis, although this issue requires further research.
- One way to reduce the costs of restocking might be to agree to an in-kind contribution from communities, so that the costs are shared between an agency and the community. In some ways, this approach can build on traditional restocking practices. Cost-share arrangements have been tried in pastoralist areas of Kenya, but have not yet been fully evaluated.

Community Participation

Restocking schemes can only succeed if the affected community is involved in the design, implementation and assessment of the project. Given that most pastoralists already have traditional systems for re-stocking, community participation should play an important part in the selection of recipients, defining the types and numbers of animals for restocking, purchase of stock, community in-kind contributions of livestock, overall management of the project and impact assessment.

This is particularly important if the constraints facing affected households and the capacity that the community and its members can contribute to the establishment of a successful restocking programme are to be addressed effectively.

Environmental Issues

Early proponents of restocking assumed that restocked households would move away from drought centres or IDP

camps with their animals and therefore, environmental degradation around such areas would be reduced. However, the relatively short duration of many restocking projects meant that environmental impacts were often not measured or attributed to restocking.

Consequently, the potential environmental benefits of restocking are not well recorded. At the stage of planning a restocking intervention, it is necessary to consider where the animals will be grazed and assess potential environmental impacts. Such assessment can be conducted with communities, using methods such as participatory mapping.

Timing of Restocking

The decision on when to implement a restocking programme needs to address the inevitable trade-off between the immediate needs of the affected population and the viability of the programme. Implementing restocking too early will result in unacceptable levels of risk to the introduced animals whilst unnecessary delays may limit the capacity of targeted households to benefit from the livestock.

At the household level, restocking may start to be considered as a viable intervention when livelihood assets have fallen below the minimum survival needs to sustain households. It has been suggested that, at the community level, this point is indicated when at least 30% of the community has been materially affected by the emergency.

The following indicators may be helpful in determining the timing of a restocking intervention:

Restocking should be carried out as soon after the disaster as possible to facilitate quick re-establishment of a pastoral way of life for those families who wish to return to pastoralism.

It is unwise to introduce large numbers of grazing animals into an area at a time when resource availability is limited (e.g. during the dry season in an arid environment). It is also important to be sure that the crisis is over before restocking. If the immediate consequences of the emergency are still apparent, livestock introduced into the area will face increased difficulty in adapting and their survival prospects may be compromised by competition for feed and water.

After drought, wet conditions are often associated with increases in the incidence of certain diseases, particularly parasitic diseases. It follows that restocked animals need to receive preventive veterinary care and restocking should only take place if such care can be provided.

Restocking is not a long-term intervention. Ideally, it should start at an appropriate time and continue only as long as is necessary for the effective re-establishment of pastoralism in the target area. These considerations should be built in at the planning stage and the following issues need to be taken into account when determining the point at which restocking should be discontinued:

At the community level, disengagement of restocking schemes should depend largely on the achievement of predetermined objectives and milestones. In the crudest sense, all the selected recipients should have received the minimum number of animals specified by the scheme before disengagement is considered.

Market Analysis

Terms of trade for livestock deteriorate dramatically during drought, and rise after the rains. This means that livestock prices are usually high at the time when restocking takes place. Agencies should take ac- count of price fluctuations when planning restocking, and assume that demand and prices for breeding females will be relatively high. Similarly, if it is known that an aid agency is about to purchase livestock, prices can increase even further.

If a large-scale programme is envisaged, an assessment of the availability of breeding females in local markets will also be needed. This kind of assessment can include a review of market sales volumes in previous years, and informal discussions with traders. In the event that animals have to be purchased from distant markets, relevant transport and other costs should be included in the project budget.

Areas for Restocking

In order to make effective use of the finite financial resources available for restocking programmes, inputs should be targeted at the most seriously affected geographical areas and vulnerable households in these areas.

Restocking operations can be implemented at community, village or household level. The decision on the most appropriate scale of operation needs to involve target beneficiary communities as well as other stakeholders.

Experience and operational logic suggest that for restocking to succeed, the focus should be on individual households within selected communities. However, the possibility of targeting the community at large, particularly if implementation is designed to complement traditional support mechanisms, should not be ruled out.

Design and Implementation of Restocking

Selection of Individual Beneficiaries

- The selection of appropriate beneficiaries has been widely recognized as key to the success of community-based programmes in general and as a major challenge in restocking initiatives. In this respect, the mechanisms by which traditional restocking takes place may provide useful indicators for an exogenous programme to aid the selection of recipients. Community leaders and a broad spectrum of representatives of the target community should be involved in the selection process. It is important that the criteria for selection of beneficiaries is established and applied publicly to allay any concerns within the community.
- As mentioned above, a key issue affecting selection is the preferred livelihoods strategy of households and a clear desire to resume a pastoral way of life. With the current pressures on pastoralism, it is possible that some people will opt to try other ways of making a living. For those households wishing to be restocked, there should also be an assessment of their capacity to manage livestock in terms of factors such as labour requirements.
- Therefore, not all of the most vulnerable households are necessarily good candidates for restocking. For example, it is possible that disabled or elderly people should receive other forms of assistance.

Types of Livestock for Restocking

- Determining the appropriate number, species, sex and age of animals to be distributed is an important part of any restocking programme. Whilst the options here will be limited, to some extent, by what is available in the market, making the right choices can have a large impact on the ultimate success or failure of the programme. Where possible, restocking programmes should draw on indigenous restocking practices as these practices reflect local interests and objectives.
- Small ruminants will often be the first choice for restocking initiatives, at least in the early stages of recovery. They are less affected by limited feed quality and availability, are relatively easy to get to market and reproduce rapidly, facilitating further rebuilding of viable flocks.
- This should not, however, rule out the possibility of restocking with large ruminants whenever there is a strong demand expressed by the community and there are adequate resources available in flood and conflict areas, for example, where pasture availability is not a major concern.
- Provision of pack animals might also be considered in response to a request from the community. Pastoral families, when offered the choice, will generally tend to opt for combinations of sheep and goats. In some pastoral societies in Kenya goats may be preferred to sheep as they are more drought-tolerant, produce more milk and sell at higher prices. On the other hand, sheep may be preferred due to their higher social or cultural value and for their more fatty meat.
- Under normal circumstances, animals for distribution should consist mainly of mature or young breeding females to promote flock or herd re-establishment and household milk supplies. Young kids without their mothers should be avoided as they are likely to suffer high mortality before reaching maturity, and recipients will not, in any case, gain an immediate benefit from them.
- Pregnant females may be desirable if available and if they do not have to trek long distances. To support good reproductive performance in goats and sheep flocks, a practical ratio of breeding males to breeding females of 1: 20 is to be preferred.
- As a general rule, restocking interventions should use indigenous types of animal because:
- These animals are likely to be well-adapted to local feed sources, climate and disease challenges
- Beneficiaries are already familiar with the management required by these animals and can there- fore be expected to take care of them properly
- They are more widely available than introduced genotypes and are normally less expensive
- Local purchasing of livestock can have knock-on benefits through the injection of cash into the local economy.
- Preservation of well-adapted but threatened indigenous livestock types is a global concern. Promoting the conservation of indigenous livestock genetic resources for current and future generations is likely to deliver future benefits in terms of the capacity of pastoralists to cope with and recover from similar emergencies.

Number of Animals Provided

- Due to resource constraints, no restocking initiative will support replenishment of all losses. Finances are also unlikely to be available to support implementation across all affected communities. A more realistic strategy is to focus on reinstating the minimum number of animals required to initiate normal reproduction of animals in the beneficiary households with a view to securing household food supplies in the next season.
- This minimum number should also allow the pastoral society to split their flocks and continue normal mobility after restocking. If this cannot happen, the pastoral households are likely to remain in their settlement areas with subsequent over-utilization of the rangeland resources around them.
- There is no standard minimum number of livestock to be provided in a restocking programme, and following the principle of community participation, this should be discussed with the community to agree on the right number in a given context.
- Using some examples, 30 breeding sheep and goats were provided with reasonable impact, although it was recommended after evaluation that 50 to 70 animals would have been better. Due to the high cost per household, it can also be possible to use a 'cost-share' arrangement in which the community agrees to provide some of the animals from their own herds.

Purchasing Arrangements

- Choice of markets - ideally, livestock should be purchased from local markets as these animals are most likely to be adapted to local environmental conditions and diseases, and transport costs will be minimized. If local markets are used, it also means that beneficiaries can be present at the time of purchase, and even select the animals they prefer.
- Alternatively, they can select a community member or relative to select animals on their behalf. Purchase of livestock for restocking from cross-border markets should be avoided where possible in order to reduce the disease spread.
- A disease of particular concern in pastoral sheep and goats is Peste des petits ruminants and it is known that the transmission of this disease commonly occurs through livestock markets.
- Livestock inspection – livestock should be inspected for signs of ill-health at the time of purchase by a trained veterinary worker such as a veterinarian or animal health technician.

Complementary Interventions: Veterinary Care

- Evaluations of restocking programmes show that losses due to disease can be dramatic. Outbreaks of diseases such as contagious caprine pleuropneumonia can cause high mortality in sheep and goats, but are preventable using relatively inexpensive veterinary inputs.
- Other health problems, such as worms and ticks can also be prevented or treated. During the initial assessment for restocking, pastoralists can identify and prioritise diseases which need to be addressed by the programme.
- Veterinary care can be considered at two main stages during a restocking programme:
- At the time of livestock purchases – livestock should be inspected for health problems, and given a one-off treatment with anthelmintic and/or acaricide as needed. A first dose of relevant vaccines might also be administered at this point. The one-off treatments can be provided by local, private veterinary workers with the implementing agency covering costs.
- After livestock distribution – recipient households should have access to basic veterinary care from CAHWs or other recognised veterinary workers. In areas where no CAHWs are present, the establishment of a CAHW system should be considered as a means to improve veterinary services for both restocked households and non-restocked households. A voucher scheme for restocked households, for say one year, may be one approach but this would have to be designed and accepted by the community as a whole.
- Monitoring, Evaluation and Impact Assessment
- Livestock for restocking should be distributed to beneficiaries in a relatively short time but it will take considerably longer to determine the impact of the programme. Even so, without an investment in effective regimes for monitoring, evaluation and impact assessment, the opportunity to learn valuable lessons for implementing similar programmes in response to future emergencies will be missed.

Some useful indicators for restocking programmes include:

- The extent to which dependence on food aid has been reduced and the time-scale over which this has been achieved

- Changes in the size of the household's herds and flocks and whether these are adequate for providing for the family
- Subsequent perceptions of standards of living before and after the emergency
- Indications of the extent to which a normal, pastoral way of life has been resumed following the restocking intervention
- Direct consumption of livestock products e.g. use of goat milk to feed children.
- This process can take three or four years to achieve and ideally will include repeated monitoring of restocked families to facilitate the identification of trends and subsequent risk factors.
- The information needed relates both to operational difficulties and to evaluating socio-economic impacts. Operationally, there is a need to monitor animal health and other husbandry practices to alert all stakeholders and perhaps organize assistance if large numbers of animals are lost due to disease, drought, or raiding.
- Data on herd or flock dynamics (births, deaths, sales and exchange of restocked animals as well as family movements) can be costly to collect but offer valuable insights into performance after restocking.

Checklist for Planning Restocking Projects

- Should we Consider Restocking?
- Can adequate funds be made available for a reasonable coverage of affected households in the target area?
- Is the carrying capacity of the area sufficient to allow the re-establishment of viable herds or flocks by recipient households?
- Are there any alternative responses that could result in a better developmental outcome for the community as a whole?
- What are the constraints and capacities that will influence a restocking programme?
- Are there procedures in place for full community consultation regarding the implementation of restocking?
- Have potential beneficiaries been consulted about their objectives in restocking?
- Is there any evidence of the following trends that may hinder the re-establishment of a pastoral way of life:
- Reduced access to former grazing areas?
- Reduced access to water sources in traditional grazing areas?
- Reduced access to transhumance routes?
- Disappearance of traditional markets?
- Loss of traditional arrangements with sedentary populations?
- Do early warning systems or other intelligence suggest an elevated risk of further disruption within the next two years?
- Are households sufficiently intact to provide adequate labour for managing herds and flocks?
- Do the requisite institutions and managerial skills required for re-establishing a pastoralist lifestyle still exist within the target community?
- Are local governments and other institutions engaged in the process?
- When should we restock and when should we stop?
- Can we identify a point at which the emergency no longer poses an immediate threat to restocked animals?
- Does this point occur sufficiently early in the recovery phase to meet the needs of affected com- munities?
- Do we have time to put in place effective arrangements for disease management or provision of supplementary feed and water for restocked animals?
- When should we make purchases of livestock for restocking so that we make the optimum use of available financial resources?
- Does our initiative include the assessment of indicators that will determine when disengagement will take place?
- Have we made arrangements for post-restocking activities (e.g. supplementary feeding, veterinary care, cost recovery)?
- Where and who should we restock?
- Have we conducted an assessment of the most severely affected areas?
- Have we linked this to an assessment of the communities that will derive the greatest developmental benefit from restocking?
- Have we determined an appropriate scale for restocking (household versus community)?

Further Reading

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2.4.10 SUB-MODULE 10: ANIMAL HEALTH CARE

The provision of veterinary services during drought and other disasters is an important strategy for ensuring pastoralists are protected from loss of their livestock and that the benefits of livestock ownership are sustained. In pastoral communities where livestock are regarded highly as a capital asset and wealth, veterinary care can help to prevent sudden loss of livestock due to acute diseases which cause high mortality. In situations where high livestock mortality occurs, it can take many years for communities to rebuild their livestock assets. Veterinary care can also reduce the impact of chronic diseases which may affect benefits such as milk production, fertility or the use of livestock as pack animals. In general, veterinary vaccines and medicines are inexpensive items relative to the economic value of livestock.

In pastoral areas of Kenya the trend in recent years has been towards the privatisation of clinical veterinary services, with increasing use of private veterinary suppliers to support primary-level workers such as community-based animal health workers (CAHWs).The emergence of these approaches in Pastoral areas demonstrates the willingness and capacity of pastoralists to pay for basic veterinary services.

Therefore, there are two main types of veterinary interventions during drought and other calamities as follows:

- Support to the private sector for primary clinical veterinary care – the prevention and treatment of livestock diseases which cause high mortality or substantial production losses.
- Support to government veterinary services, particularly for disease surveillance, disease control, veterinary public health, and other functions as needed.

Intervention Strategy

If drought becomes very prolonged the need to support core public sector veterinary functions should be considered.

Coord.ination

The MoALFC is responsible for coordination at National level and the County Veterinary Departments ensure veterinary programs are implemented at County level, during drought or other disasters. This coordinating bodies for Veterinary inputs should be viewed as complementary to other forms of drought assistance, such as supplementary

feeding, and good coordination should ensure that appropriate combinations of different interventions are used.

Some of specific functions of coordination as they relate to veterinary interventions are as follows:

Initial assessment – ensuring timely and accurate assessment of veterinary needs, encouraging joint assessment with all key actors working together, and making information available to assessment teams.

Funding mechanisms – coordination and preparation of funding proposals, with assignment of operational areas and technical roles to agencies with relevant experience and technical expertise.

Design of interventions - harmonisation of primary veterinary service design and implementation strategies among agencies working in a disaster-affected population, and between affected and adjacent unaffected populations as needed; ensuring that interventions fall within government policy and that any training inputs use existing government standards and guidelines; ensuring that interventions fall within international standards and guidelines.

Monitoring and evaluation – coordination should include monitoring of the overall intervention and real time adjustment of strategies and activities as needed. The use of standardised monitoring forms assists the collation of monitoring data on a programme-wide basis. This is particularly important for veterinary interventions because relatively limited information is available on the impact of veterinary inputs on livestock production and mortality, and any associated benefits to pastoralist communities.

Guidance on Disease Surveillance

In pastoral areas of Kenya, international trade in livestock or livestock products is an important aspect of livelihoods. This trade is influenced by international animal health standards and the use of disease information to determine the risk of Kenya exporting livestock diseases to trading partners. The major source of disease information is the Directorate of Veterinary Services and livestock disease surveillance system and therefore, disease control activities need to be designed in collaboration with the Directorate.

Routine monitoring - the monitoring of clinical activities of para-veterinary workers such as CAHWs can contribute to a livestock disease surveillance system. Routine monitoring can include the recording of livestock disease events, in addition to the treatment or control measures used. Such data is most useful if livestock morbidity and mortality by species and disease is recorded in relation to the population at risk - treatment or vaccination figures per se have limited value unless related to specific populations of different livestock species. For CAHWs, pictorial monitoring forms have been used successfully in Kenya and are particularly useful for CAHWs with low levels of literacy. Monitoring tasks should be designed in collaboration with government veterinary services.

Veterinary investigation – There are several regional Veterinary investigation Laboratories in the country which have capacity to conduct investigations of disease outbreaks including post mortem examination and laboratory diagnosis The laboratories carry out regular reporting of disease outbreaks and strategies for control and quarantine can then be implemented.

Reporting - in protracted crises, all agencies should submit regular disease surveillance reports to the Veterinary Services Authority, which in turn, should compile and share information with relevant partners.

Veterinary Public Health

Veterinary public health covers the prevention or control of animal diseases which are transmissible to humans either through food or by contact between animals and people; it is a key public sector function. These zoonotic diseases include anthrax, salmonellosis, tuberculosis, brucellosis, manage and Rift Valley fever. Drought or other disasters can result in abnormal livestock movements or use of grazing areas, high livestock mortality followed by scavenging of carcasses by wild or domestic carnivores, crowding of livestock, or close contact between livestock and people. These conditions can increase the risk of zoonotic diseases in livestock and humans. The disease control method depends on the disease in question and in some cases, collaboration between veterinary and human health services is justified.

Examples of veterinary public health activities during drought or other crises include public education campaigns to control Rift valley fever, tuberculosis , brucellosis etc e.g. through hygiene and consumption of boiled milk, or public awareness and mobilisation to collect and bury or burn animal carcasses.

Assessment - rapid participatory assessment conducted under the provision of primary-level clinical veterinary services should include a rapid assessment of zoonotic diseases, in terms of actual cases or potential risk of disease occurrence. In emergencies, anthrax may be associated with abnormal movement of livestock to grazing areas which are normally avoided; rabies may be associated with local populations of wild or domestic predators, possibly attracted to carcasses or garbage; other zoonotic diseases may be associated with close contact between animals and people, or unhygienic conditions arising from the crowding of people and animals in camps, or the breakdown of water supplies.

Zoonotic disease control - the control method will vary according to the zoonotic disease(s) in question. For some diseases, information to livestock keepers might be transferred verbally or using leaflets delivered by para-veterinary workers as an addition to their routine clinical work. Where private veterinary workers are used on a short-term basis, payment for their services by an aid agency will usually be required. Zoonotic disease control efforts between agencies and between areas should be harmonised as part of the coordination effort. Collaboration with human health agencies and programmes is beneficial to harmonise approaches and for sharing of resources.

Euthanasia and disposal - disasters may result in large numbers of injured or terminally sick animals, which require euthanasia and disposal. Animals dying as a direct result of disaster injuries also require disposal. Animal carcasses may spread disease, are unsightly, produce noxious odours and attract predators and scavengers such as packs of dogs, hyenas or jackals. Animal euthanasia should follow humane standards and practices. Depending on the sickness, injury and method of slaughter, some livestock carcasses can be fit for human consumption.

Slaughter facilities and meat inspection – in emergency interventions in pastoral areas of Kenya, attention to slaughter facilities and meat inspection is particularly relevant to slaughter destocking. In camps for displaced pastoralists it may be appropriate to construct slaughter slabs to encourage the humane slaughter of animals by trained workers, the hygienic handling of meat, and meat inspection. In all cases, consultation with local livestock workers or butchers will help to determine the correct locations for slaughter slabs, and their design. Meat inspection procedures are generally well known. Safe disposal of offal from slaughtered livestock should be ensured.

Clinical Veterinary Care: General Approaches and Principles

Preventive and curative veterinary interventions during drought fall into two broad categories: the examination and treatment of individual animals or herds, and tactical and strategic treatment or vaccination programs.

The principle of choice, in which livestock keepers are able to select the type of preventive or curative service they require for all diseases other than those covered by official disease control policies. In common with primary medical services, veterinary services should be accessible, available, afford- able, acceptable and of sufficient quality. In drought in pastoral areas of Kenya two of these characteristics of service provision are particularly important.

Accessibility - in remote areas with poor infrastructure and communications, veterinary service delivery is a challenge even in normal periods. Access to communities might only be achieved on foot and in general, the more remote a community, the more vulnerable it is during a disaster. Para-veterinary workers such as CAHWs are usually the most appropriate service providers in these situations because they are able to travel and function in these environments. Therefore, supervised and well-trained CAHWs should always be considered as potential veterinary service providers.

Affordability and payment for services - experiences in pastoral areas of Kenya show that when private clinical services are based on simple community-based approaches with low transaction costs, even the poorest livestock keepers will use these services. In drought or other disasters, the issue of affordability is a particular challenge for agencies aiming to provide rapid, equitable and effective clinical veterinary care, while also trying to support local, private service providers who require an income. Approaches such as sub-contracting local private veterinary workers or the use of voucher schemes warrant wider use and assessment. These schemes can reach poorer and more vulnerable livestock users, while also helping to maintain private facilities during disasters. In contrast, there is little evidence to show that the provision of free veterinary care on a large scale and delivered directly by aid agencies or government during disasters overcomes equity problems or provides significant livelihoods impact.

When designing the provision of primary clinical veterinary services during drought or other disasters the trade-offs between the free provision of services and some form of payment by livestock keepers need to be considered.

Free service delivery - if delivered free-of-charge, the coverage of a veterinary service will depend on the availability of funding by external agencies or government due to disparity between the level of funds available and the size of the population to be reached. In some cases, only a small proportion of a drought-affected population will be accessed. The decisions about which types of livestock and diseases to treat, and the method of treatment, are based on the objectives of specific agencies and the clinical judgments of veterinary workers on the ground. If clinical services are delivered by aid agency staff in isolation of local veterinary services providers, there is a risk of undermining local services. Furthermore, unless closely supervised there is a risk that free services are not actually delivered and users are charged at the point of delivery. Alternative systems of clinical veterinary service delivery aim to use existing veterinary workers where they exist, or, conduct rapid selection and training of para-veterinarians. These approaches help to strengthen local capacity and support systems which can be improved over time and as the drought wanes. Again, if services are provided free-of-charge, service accessibility and availability will depend on the level of funding available.

Payment for services - if payment for services is used, accessibility and availability can improve, although the issue of affordability becomes important. A third approach involves the gradual introduction of payment for services, with free provision during the acute stage of an emergency and payment for services in later stages and as livestock markets begin to function. In Kenya, veterinary services are in a state of transition from government to private sector delivery of clinical veterinary care. Therefore, an important aspect of the provision of clinical veterinary services during disasters is to work with private sector veterinary facilities and workers wherever possible. Such service providers can comprise the main source of quality veterinary care after drought. During a drought they can be subcontracted to deliver veterinary services, or can provide services through mechanisms such as voucher schemes. In general in Kenya, most veterinarians are located in major cities and towns. In remote, rural or marginalised areas veterinary care is provided by para-veterinary workers. The categories of para-veterinary workers include veterinary assistants, animal health technicians and CAHWs. Different strategies for emergency veterinary care are needed according to the pre-existence or not of local veterinary workers in the disaster-affected area.

Agencies considering the provision of clinical veterinary care have to understand the trade-offs between these different approaches. In terms of the principles of livelihoods-based programming, there is very limited evidence to show that the free provision of clinical veterinary care to individual animals provides significant livelihood benefits to disaster affected populations, or is cost-effective or equitable. Relatively more evidence of livelihoods benefits is available for para-veterinary systems based on some level of payment for services, particularly in protracted crises, where studies show reduced livestock mortality and improvements in service accessibility, availability and acceptance at a population level.

Guidance on the Timing of Veterinary Interventions

Veterinary interventions can be appropriate at all stages of a calamity, but should be combined with other forms of assistance. Support to basic clinical veterinary services will help to ensure that sick animals are treated promptly. It should be noted that livestock vaccination should be completed before drought occurs. Of the various diseases prevented by vaccination, only anthrax is particularly associated with drought as animals may move to anthrax-infected areas due to limited grazing elsewhere. During other crises all possible veterinary interventions could be considered.

Guidance on supporting basic services for the examination and treatment of individual animals or herds through the services of supervised CAHWs, emergency veterinary interventions during drought and other calamities can aim to provide a clinical service to pastoralists and treat sick livestock. Such services can provide immediate benefits to those users who can access the service.

Assessing Needs of Vulnerable Groups

The design of equitable and effective primary veterinary service delivery requires an understanding of livestock ownership or use by different socio-economic groups within a population. In particular, the assessment should include an understanding of the following:

- Livestock owned or used by women - vulnerable groups such as female-headed households may own specific types of livestock such as poultry, small ruminants or donkeys, and therefore it is important to consider the main health problems affecting these animals. Women and girls may be responsible for small and/or

young stock, including the diagnosis and treatment of livestock diseases and hence may have significant ethno-veterinary knowledge which should be taken into account in planning. Women are also commonly more vulnerable in emergencies to food insecurity and other threats. Therefore, they should be involved in animal health interventions, including specific targeting of particular activities and the recruitment of women CAHWs where possible and appropriate.

- People living with HIV/AIDS – for people with HIV/AIDS the prevention of zoonotic disease is particularly important. In addition, livestock products can provide substantial nutritional benefits to people living with HIV/AIDS. Increasing the productivity of livestock through animal health interventions can therefore also have a positive impact on these groups in particular.

Context Analysis

In addition to the particular needs of certain subpopulations within communities, the assessment should take account of security and environmental issues.

Security factors - the security implications of any animal health intervention should be considered. For example, CAHWs carrying cash and/or medicines may be at increased personal risk of robbery or attack. Insecurity can also have animal health implications: animals stolen from a neighbouring group or area can bring disease.

Policy and legal factors - the assessment should include a rapid review of government agency and do- nor policies, rules or procedures which relate to implementation options. There may be restrictions on the use of certain types of veterinary products by certain levels of veterinary workers. The use of funds from some donors to buy veterinary input is governed by bureaucratic donor requirements which pre- vent rapid and appropriate procurement in emergency contexts.

Approaches and Methods for Rapid Participatory Assessment

General approach and timing - during drought or other disasters the assessment of veterinary capacities and needs should be conducted rapidly and use participatory approaches and methods. The initial animal health assessment should be carried out during the alert phase of a calamity. Best practice for rapid participatory assessment of veterinary capacities and needs include:

Stakeholders -the assessment should involve all relevant sub-groups within a drought or disaster-affected population and should be conducted in partnership with local veterinary authorities and service providers, and/or with other groups as relevant.

Skills and experience of assessment team - the assessment should be conducted by veterinarians who have been trained in participatory approaches and methods, and who are experienced users of these methods in pastoral areas of the country.

Methods for assessing veterinary services - The assessment of existing veterinary services and possible gaps in service provision should be based on the use of five key indicators viz. accessibility, availability, affordability, acceptance and quality; useful participatory methods to measure these indicators are also listed below. Participatory mapping is particularly useful as a rapid assessment method. It can quickly show existing service providers such as veterinarians and all types of para-veterinary workers working in the public and private sectors, and for NGOs or UN agencies. Understanding the activities and coverage of these workers will assist agencies to define a strategy for service delivery, including ways to fill gaps in terms of coverage or access to vulnerable groups.

Information derived from participatory methods should be cross-checked against secondary data when available. Secondary data includes government disease surveillance reports, disease studies from local research institutes and published data. Cross-checking (triangulation) of information in this way helps to ensure that the overall analysis is as rigorous as possible within the time available. Formal livestock disease surveys involving questionnaires and laboratory diagnosis are rarely feasible in disaster con- texts, and the modest added value of the disease information obtained is rarely justified in relation to the additional time and cost required, and the need for rapid action.

Guidance on the design and implementation of clinical veterinary services

Following the common principle of community participation pastoralists, including vulnerable groups, should actively participate in the design of emergency veterinary interventions during drought or other crises. They include:

Type of intervention - the veterinary intervention during an emergency could generally be curative, preventive and supportive treatments based on the initial assessment results. Vaccination of livestock during peak emergency situations is discouraged and avoided unless and otherwise it is strongly suggested as an outcome of the initial assessment process. Livestock vaccination should be conducted in a strategic way and based on epidemiological findings during normal, alert and/or recovery stages of the drought management cycle.

Payment for services - the animal health intervention should be based on the principle of partial or full payment at all times. When the results of a rapid participatory assessment justify that livestock owners are unable to pay for the inputs and services, partial or total cost will be borne by aid agencies and/ or other actors including the government. Such a subsidised operation must last only for a short duration of time and has to be decided prior to the implementation of interventions. Voucher or coupon systems could be implemented for effective service delivery and to discourage misuses. Animal health interventions during emergencies must support local private actors and could involve CAHWs, private practitioners and drug vendors. Good coordination is needed to define the roles and responsibilities of private sector actors, government and NGOs.

Focus on important diseases – the service design should aim to address the prioritised livestock health problems which are identified during the initial assessment. It is rarely feasible or appropriate for an emergency, primary-level veterinary service to address all livestock health problems and in most cases, a limited range of veterinary vaccines and medicines can be used to prevent or treat the most important diseases in a given area. The focus of the service on prioritised livestock diseases needs to be understood and agreed by all actors, including livestock keepers. Similarly the appropriate timing for interventions particularly vaccination should be discussed and agreed with all stakeholders.

Vulnerable groups - service design should take account of the types of livestock owned or used by vulnerable groups, and should aim to address the main health problems in these livestock. Vulnerability in terms of primary veterinary service delivery also requires special attention to accessibility and affordability issues. Accessibility to more remote areas with limited infrastructure by conventional means requires considerable cost and therefore limited coverage, or the use of para-veterinary workers who are able to travel on foot or local transport. In some cases, programmes may need to provide or support local modes of transportation for veterinary workers.

The strategy for payment for services needs to take account of the need for rapid and equitable delivery, while also supporting private sector veterinary workers where possible. For more vulnerable groups, private veterinary workers can be subcontracted by agencies to deliver a service for a specified, short time period. Voucher schemes are a variation of this approach, in which selected livestock users are provided with a voucher which allows them to access private veterinary care up to a specified value. The private veterinary workers then exchange the vouchers for cash from the aid agency. In areas where a private veterinary sector is active or where government charges for clinical veterinary care, the continuation of normal pricing policies should be followed, other than for targeted vulnerable groups. To avoid confusion, community participation and agreement with community representatives is needed.

Procurement and storage of veterinary medicines - there is considerable variation in the quality of veterinary vaccines and medicines sourced from different suppliers, either locally or internationally. Suppliers also vary in their capacity to supply large volumes of drugs with appropriate expiry dates, and according to agreed delivery times. Procurement can be further complicated by the range of diseases in different livestock species, and the wide range of products available to prevent or treat a particular disease. When using veterinary vaccines, some vaccines require the isolation of local field strains of disease pathogens to ensure adequate protection and therefore the exact composition of these vaccines needs to be verified. Agencies with limited experience of veterinary drug procurement should seek expert advice. Local importers, mostly based in Nairobi, can be a source of readily available drugs in reasonable quantities. However, the quality, expiry date and prior storage of these drugs need to be checked. At field level, most veterinary vaccines and some drugs require cold storage. They should not be purchased or used unless adequate cold storage facilities are in place. Cold storage facilities of human health services can sometimes be shared.

Training inputs - in situations where some veterinary workers are already present and where rapid delivery of services is required, training should be limited to short refresher courses focusing on the clinical diagnosis of the prioritised diseases, and the correct use of veterinary vaccines or drugs. The need for such refresher training is determined by the existing capacity of local personnel. If para-veterinary workers such as CAHWs need to be selected and trained from scratch, guidelines are available for CAHW systems in

Kenya although these guidelines refer to development rather than emergency programmes. In emergency situations where rapid delivery of services is required, it may be necessary to streamline and shorten some of the best-practice principles related to CAHW selection and training. However, as emergencies become protracted or end, further training to enhance CAHW knowledge and skills is recommended.

Social and cultural norms - the design of veterinary services needs to take account of local social and cultural norms, particularly related to the roles of men and women as service providers. In some com- munities it is difficult for women to move freely or travel alone to more remote areas where livestock might be present. However, even in very conservative communities it is often possible to select and train female CAHWs to provide a service to women, who are often among the most vulnerable groups.

Security issues - service design should take account of the possible exposure of veterinary personnel to violence, abduction or theft. Livestock are often grazed away from more secure settlements, and some- times have to be moved long distances to grazing areas and water points. In conflict situations, veterinary workers travelling to such areas may be at risk. In part, the use of local para-veterinary workers can be appropriate in these situations because these workers know the local area and the relevant armed groups or security forces, and are able to negotiate access. In areas where livestock are very important to local economies and livelihoods, veterinary drugs are highly prized and as small volume and high value items are easy to loot and re-sell.

Roles and responsibilities - many of the problems which arise during emergency veterinary service provision are associated with misunderstandings about the roles and responsibilities of different actors, false expectations regarding the aims and coverage of the service, or confusion over pricing arrangements or selection of beneficiaries. Many of these problems can be avoided by a commitment to community participation and where possible, close collaboration with local authorities and private sector actors. Roles and responsibilities should be documented in Memoranda of Understanding or similar agreements. Such agreements act as a very useful point of reference in the event of disputes.

Mass Treatment and Vaccination Programmes

This section summarises some key technical aspects affecting the impact of vaccination and advises veterinarians and livestock programme managers to consult OIE guidelines. Although the design of vaccination programmes varies according to the epidemiology and impact of different diseases, veterinary professionals are advised that:

Disease diagnosis - failure to diagnose disease(s) according to recognised international diagnostic standards increases the risk of inappropriate vaccination e.g. through the use of the wrong vaccine.

Vaccine composition - for some diseases, vaccine efficacy is highly dependent on the identification of local field isolates and the inclusion of these isolates in the vaccine. This is a particular issue in the case of vaccines for hemorrhagic septicemia and the various forms of bovine and ovine pasteurellosis. Agencies conducting vaccination should check with vaccine suppliers that the composition of vaccines is relevant to the diseases and specific pathogens in their geographical areas of operation.

Vaccine efficacy - although some vaccine producers may cite results of their own laboratory-based vaccine efficacy trials, such trials require large sample sizes, relevant livestock species and a capacity to reproduce natural infection in laboratory settings. For these reasons, reference to peer-reviewed literature and/or the guidelines provided by OIE and FAO is advised.

Vaccination protocols - when using vaccines, the level and duration of immunity varies according to the vaccine, number of doses and timing of doses.

Foot and mouth disease (FMD) is a severe, highly contagious viral disease of livestock that has significant economic impact. The disease affects cattle, swine, sheep, goats and other cloven-hoofed ruminants. The organism which causes FMD is an aphthovirus of the family Picornaviridae. There are six strains (A, O, C, SAT1, SAT2 and SAT3) which are endemic in different countries. Each strain requires a specific vaccine to provide immunity to vaccinated animals. Vaccination is the common control method designed to achieve mass coverage or targeted to specific animal subpopulations or zones. It is important to use inactivated virus vaccines, as inactivated viruses do not have the ability to multiply in vaccinated animals. The use of live virus vaccines is not acceptable due to the danger of reversion to virulence.

Timing of vaccination in the face of outbreaks of FMD, anthrax, hemorrhagic septicemia, pasteurellosis and blackleg, vaccination of affected herds is unlikely to reduce mortality unless it is conducted before mortality peaks in a given herds. If vaccination is conducted after peak mortality has occurred, it is unlikely to affect mortality. Furthermore, delayed vaccination using only a single dose of inactivated vaccine tends to produce immunity of short duration or no immunity (depending on the vaccine type). Therefore, such vaccination may not prevent future disease outbreaks.

In many pastoral areas, outbreaks of FMD, anthrax, hemorrhagic septicaemia, pasteurellosis and blackleg are predictable because the diseases are either location-specific (e.g. anthrax) and/or seasonal. Failure to complete a full vaccination course for these diseases before periods of high risk, and/or failure to cover a high proportion of animals in a given herd, reduces the impact of vaccination.

Cold storage - many vaccines require cold storage. Failure to comply with manufacturer's recommendations for cold storage increases the risk of ineffective vaccination. In hot pastoral areas, particular care is needed to ensure correct storage of vaccines.

Disease control policy - in the case of contagious bovine pleuropneumonia, contagious caprine pleuro pneumonia and Peste des petis ruminants, the design of vaccination programmes should be the subject of national disease control programmes and strategies.

Monitoring of Veterinary Service Provision

Clinical veterinary services in droughts and other crises should be monitored systematically and with sufficient frequency to enable rapid detection and correction of problems, either by the county veterinary Department or the agencies on the ground.

Monitoring approach and timing – following the common principle of community participation, the monitoring system should include regular consultation with community representatives, community members, vulnerable groups and other relevant stakeholders including CAHWs, private practitioners, NGOs and local authorities. Each of the five main monitoring indicators for veterinary service provision can be measured using participatory methods.

Monitoring should occur at least once a month. The monitoring system should include the monthly submission of monitoring reports by veterinary workers to the aid agency and/or County Veterinary Department. These reports should detail the activities of workers in tabulated form, and should complement measurement of the five main indicators of service provision detailed below.

The outputs from monitoring exercises should be timely communicated to all relevant stakeholders including the local veterinary services authorities.

Indicators for monitoring service provision - there are no internationally-recognised standard indicators for measuring primary veterinary services. Indicators for primary human health services can be applied to veterinary services, and five useful indicators are accessibility, availability, affordability, acceptance and quality. The methods used to assess these indicators during an initial assessment can also be used to monitor progress over time. Given the need to reach vulnerable groups, each indicator should not only measure service provision in the population as a whole, but also service provision for specific vulnerable groups. Accessibility, availability and affordability can be measured quantitatively, whereas acceptance and quality can be measured quantitatively and/or qualitatively.

Indicators for measuring livestock diseases - monitoring systems for clinical veterinary services should contribute to official disease surveillance systems. Therefore, monitoring should include the collection of information on livestock disease incidents, and use indicators such as the proportion of animals affected by disease and livestock species, and mortality by disease and livestock species. For preventable diseases, this process assists the project to assess whether veterinary service provision is reducing diseases according to the prioritised list of diseases identified during the initial assessment, and whether other or new diseases should be addressed. The monitoring system should also track outbreaks of particularly important livestock diseases and inform responses as necessary as shown below.

Process indicators		Impact indicators
Designing the system	Completion of participatory survey and analysis Number of meetings with community/ community representatives	Identification of the ten most important animal health problems in the community according to different wealth and gender groups Analysis of options for improving animal health Agreement on action to be taken
Links to drug outlets	Number of meetings between private veterinary workers and agency	Agreement between parties Number of para-veterinarians linked to private veterinary drug supplier or agency
Rapid veterinary training	Number of workers trained Number and type of animal health problems covered in training course Geographical location of workers Cost of training	Improved veterinary knowledge and skills among trainees
Veterinary worker activities	Number of starter kits supplied to veterinary workers Cost of starter kits supplied Quantities and types of medicines supplied to veterinary workers Cost of medicines supplied to veterinary workers Number of treatments per disease per livestock type per worker per month Number of vaccinations per dis- ease per livestock type per worker per month Income received by veterinary workers Number of monitoring forms sub- mitted by veterinary workers Number of disease outbreaks reported by veterinary workers	Livestock mortality over time Geographical coverage of veterinary workers Proportion of livestock-rearing house- holds serviced by veterinary workers Proportion or number of workers functioning after training Drugs and vaccines resupplied to CAHWs based on revenue collection Action taken according to disease outbreak reports Food consumption in community related to improved animal health and according to wealth and gender groups Income in community related to improved animal health and according to wealth and gender groups Influence on policy

Policy Implications

The policies for veterinary care in pastoral areas during drought or other emergencies relate to policy on veterinary service provision and policies on disease control.

Policy on veterinary service provision – the MoALFC recognises the economic and production benefits of mobile livestock rearing systems in pastoral areas of the country and consequently, supports veterinary service delivery which best meets the needs of mobile communities and their herds. To date, the most effective means of service delivery has been private CAHW systems which are properly designed and maintained with appropriate supervision from veterinarians. These systems fall within international standards set by the World Animal Health Organisation. All agencies are advised to follow the Directorate of Veterinary services National Minimum Standards and Guidelines for the Design and Establishment of Community-based Animal Health Worker Systems, and conduct proper monitoring and evaluation of these systems.

Policies on disease control – the development of disease control policies for specific livestock diseases in pastoral areas has been hindered by the limited information available on the epidemiology and economics of diseases in these areas. During normal periods, between droughts or other crises, all actors involved in veterinary services in pastoral areas are encouraged to conduct studies on livestock diseases and as far as possible, work with the Directorate of Veterinary Services to design disease control strategies to be implemented by the private sector, or as public-private partnerships. Participatory epidemiology approaches and methods are well suited to pastoral areas and require further use by government services, research institutes and NGOs.

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2.4.11 SUB-MODULE 11: WATER FOR LIVESTOCK

Introduction

The provision of water for animals in an emergency focuses on the survival of livestock assets through and beyond any disaster. In the absence of sufficient water supplies, animals (with the exception of camels) cannot survive for more than a few days. Therefore, in emergency situations where water sources have been seriously compromised, the provision of alternatives is of the highest priority. Even where water is currently available, relief programmes need to assess, and if necessary, implement appropriate responses to potential and future threats to water sources to ensure that other relief efforts are not undermined by water shortages. Whilst water for livestock must meet some basic quality requirements, the quality standard is not as high as that for human consumption, and therefore livestock can make use of water sources otherwise unfit for humans.

The practical implications of providing water to livestock should be considered carefully and in parallel with the need for animal feed and veterinary care. Proper cost-benefit analysis will be critical in deciding whether various interventions are sensible and effective in the long-term.

In certain situations such as chronic disasters drawn out over time, emergency interventions may disrupt or go against the promotion of natural coping mechanisms or development planning. Dependency on emergency handouts can also be counterproductive. An understanding of drought cycles in Kenya and 'drought cycle management' is useful when investing time and money into emergency interventions. All interventions should therefore aim to complement long-term development goals in the area.

Options for Water Provision

Water may be available from a range of sources and deliverable by a number of means. This can at times complicate, or ease the selection of appropriate interventions capable of matching supply with demand. As a rule, the most cost-effective, sustainable and secure options need to be selected. However, the need to distribute water effectively is often so acute that expensive and unsustainable methods such as water trucking may need to be considered in the short term at least.

In an emergency situation, access to water may be provided for livestock owners in one of three ways:

- Improving the management and capacity of existing water points to provide broader access to affected populations.
- Rehabilitation of existing but degraded water points.
- Establishment of new water points.
- Typical water sources in Kenya may include:
- ground water sources (e.g. hand dug wells, boreholes and spring protection schemes)
- surface water harvesting systems (e.g. direct extraction from rivers, lakes and ponds, check dams and subsurface dams)
- rainwater collection (e.g. roof collection, 'birkas' and 'haffir dams')

The principles underlying the establishment of differing water supplies and the issues that must be addressed in managing them effectively are broadly the same.

Distribution

After the identification and selection of potential water sources has been made the focus of attention switches to the various methods of distribution. Distribution may be achieved in a number of ways:

- by hand (e.g. using buckets, local pots, jerry cans etc.)
- by animal traction (e.g. donkey carts/saddle bags, use of camels)
- gravity (e.g. open channels, pipelines, hydraulic ram pumps)
- Pumping (with associated pipeline networks)

Trucking

Providing appropriate distribution points associated with various water sources will invariably offer the most viable, longer-term solution to the problem of water shortages for livestock as compared to other key options. A sustainable management plan for the operation and use is imperative and should be considered at the initial stages of an emergency.

Water trucking, as one form of distribution, deserves a special mention here since this intervention should generally be regarded as an option of last resort to be considered in the first stages of an emergency only. It is expensive, resource inefficient and labour intensive. However, due to the critical nature of the impact of dehydration on livestock, it may be the only option that can be implemented rapidly in order to keep animals alive in the short-term. As a rule, therefore, trucking should be regarded as a temporary intervention that will be replaced, as soon as possible, by other means of distribution or eventual relocation of livestock.

Complementary Interventions

The provision of water may be complementary to other livestock-based emergency responses, in particular supplementary feeding and destocking, whereby some animals are taken out of the production system and efforts such as the provision of water and feed are made to ensure the survival of the remaining stock. Coordination between initiatives and between agencies is therefore paramount to avoid one activity undermining another.

Assessments of Water Sources

The proper assessment of water sources provides for the rapid identification, assessment and categorization of available human and physical resources, whether in the field or not, to maximise the benefits for existing and temporary populations and livestock within the disaster-affected area. In addition to technical issues, the assessment needs to consider various socio-economic and targeting issues.

Vulnerability of specific groups within communities - ensuring water reaches the most vulnerable livestock owners during an emergency presents a number of challenges. For example, wealthier owners may be able to secure private means to provide water for their animals, which are not open to poorer households. Interventions should therefore take into account the constraints facing vulnerable groups within the community to ensure that access is as equitable as possible. Gender roles in the provision of water for livestock should be taken into account, particularly for poorer women and girls who may be at risk of, for example, violent assault or exploitation if they have to travel some distance to bring water for stock.

Indigenous water management - disaster-affected communities invariably draw on their own capacities to respond to emergencies, for example in their indigenous knowledge of natural resources; in particular the location,

type and quality of water sources and the relationship between those sources and their management. Local water management systems and indigenous institutions may also play a significant role in the management of water points and will remain pivotal in the avoidance of conflict. It follows that existing and indigenous local water point management systems must be taken into account in the provision or establishment of water sources during an emergency, in order to help provide equitable access, avoid conflict and establish sustainable management for the future.

Security and protection issues - the security and protection of water users should be taken into account: for example, people, and in particular women, watering their animals at communal water points may be vulnerable to livestock rustling or robbery. Waterpoint management must be addressed prior to rehabilitation or establishment in order to avoid potential ownership conflicts. Issues of water management are particularly important to ensure the protection of water users around IDP camps - for example, when the camp residents need access to water points outside the camp for their livestock, they may come into conflict with the host populations. Negotiation with all stakeholders beforehand may help to minimise potential conflicts.

Environmental considerations - are important in the provision of water for livestock in emergencies. Care must be taken to avoid excessive extraction (either through the density of water sources or high extraction rates) which affects the water table; and high concentration of livestock around water points. On the other hand, water provision – when provided in accordance with well-thought-out natural resource management strategies - may have a positive impact on the environment by encouraging more effective natural resource utilisation.

Water for people versus water for livestock - it is important to ensure that human water supplies are not contaminated by livestock. Similarly, conflicts between the demands of the human population and their associated livestock will often be an issue. With proper planning and management, it should be possible to create a network of distribution points that will protect the quality of water supplies and meet the demands of both humans and livestock.

Key steps and principles for the assessment of water sources

The key steps and principles for the assessment of water sources are detailed below.

Collate Background Information

The assessment team should collect and collate relevant background information before it leaves for the field assessment. The collection of background information prior to departure to the field is useful in many ways. First, it allows the team to start to acclimatise to the situation on the ground and to gain an overview of the difficulties one may encounter in the field. Gathering of background information should include as a minimum the collection of maps (topographical, geological, hydrogeological, and satellite imagery if possible), land-use and rainfall data, names of other agencies working in the field, and key personnel. This process will allow adequate time to reflect on the prevailing political and demographic situation and what difficulties may arise during the implementation of programs.

A series of at least cursory visits to relevant government agencies, national and regional, local, and in- international NGOs will help to form an opinion of their capabilities, activities, and incumbent strengths and weaknesses.

In carrying out an assessment, the principle should be to collect enough data to implement an effective response. Time spent collecting unnecessary information is time wasted.

Rapid Participatory Assessment

Local people usually possess detailed knowledge of water sources, including locations, quality and the available amount of water. Access to water is normally the primary reason for human concentration in any specific area during an emergency and this factor is even more pronounced where livestock are concerned. Consequently, participatory assessment with local or displaced communities and access to indigenous knowledge are paramount. One of the most effective methods for rapidly determining the location, demand, discharge, management issues and alternative sources is participatory mapping; an exercise that may take less than an hour or two even with large groups of people (see Annex 5.1). Various other participatory methods are also useful, including matrix ranking, transect and focus group discussions. The assessment team should be familiar with these participatory methods and know-how to apply them to water source assessments.

In parallel with participatory methods, more formal engineering techniques can be used to confirm local knowledge and to provide specific technical solutions for the provision of water to livestock. These may include, for example, direct observations, structured interviewing, topographical surveying, geo-technical/hydrogeological surveys, laboratory-based analysis of water quality using specialised equipment either in the field or at the nearest urban centre.

Coordination Issues

As a minimum, contact should be maintained with regional government bodies, parastatal, bilateral, UN and NGO agencies with an interest or specific remit within the livestock and pastoralist sector, and those with responsibility within the water supply sector in general.

In any emergency in Kenya the federal DPPA is tasked with coordinating all external interventions, assisted by regional governments. It is important to avoid duplication of effort and/or following antagonistic approaches to providing assistance since this may simply cause more harm than good.

Water Source Selection and Intervention Design

Proper determination and analysis of all known variables and parameters within the time available to the assessor should ensure the selection of the most appropriate single or multiple sources of water. Planned interventions should be negotiated with all relevant stakeholders to avoid conflicts of interest.

Supply and Demand

The relationship between supply and demand is a simple one and the impact of this relationship will be easily recognisable within days of an acute emergency event. Should demand outstrip supply the first and most obvious indicator will be rapid depletion of livestock assets. Secondly, conflict within the existing population may exacerbate the emergency situation and cause further migration to unsuitable areas where livestock depletion may continue. Rapid assessments of available supplies and demand are therefore required at a very early stage and should the need for water trucking be approved in the short- term, arrangements should be made immediately to avoid such negative scenarios occurring.

Demand assessments should be based on best estimates derived from livestock population figures, local authority records and consultation with locally-affected populations. In addition, livestock traders and middle-men may be able to offer useful information in some areas. Ease of collection of water and its accessibility to animals need to be considered here. If livestock are to drink at the water point, then demand assessments should take into consideration reasonable walking distances to determine the area to be covered by the water point.

The ‘storage’ of water should not be overlooked in determining the quantity of the most insignificant source. For example, the trickle from a leaky tap could supply enough water to satisfy 180 goats (based on a yield of 0.5litres/minute for 12 hours), if captured overnight. The overflow and waste water collected from water points dedicated to human needs is often enough to satisfy household livestock assets provided that proper drainage and delivery troughs are incorporated into water point designs.

Costs associated with water provision

In deciding whether to rehabilitate, renovate and/or improve the yield of existing water points as opposed to creating new water points the critical parameter is usually defined by the overall cost of delivering a cubic metre of water over the expected duration of the emergency. This type of cost-benefit analysis will quickly determine whether the aims and objectives of the agency are not only realistic but viable in the medium to long term. If relocation or alternative solutions are cheaper than these should be implemented.

Distribution

To reduce costs, avoid conflict and prevent contamination, access to and the collection of water for livestock should be controlled, efficient and appropriate to the type and number of livestock present.

Distribution networks and watering - to speed the watering of livestock it is recommended that water be transferred from the selected source by an appropriate distribution network to a well-designed and purpose-built watering facility. The physical transfer of water can be achieved through animal or human traction or preferably through an open

channel or piped distribution network. The distance from source to watering facility need not be too long. The design of the watering facility will take into consideration the method of delivery from source, the optimal movement and flow of livestock through it, animal holding requirements, drainage, associated management facilities and additional security requirements. Gender and issues relating to vulnerable groups should be taken into account.

Watering of animals and human activity - in the design of purpose-built watering facilities it is possible to ensure from the very beginning that human activities are effectively separated from livestock watering. In situations where existing facilities are necessarily being used for both live- stock and human consumption basic improvements can be made to separate human activities from livestock watering. Collecting waste water and improving the drainage is often the easiest and fastest way to achieve minimum separation. Gravity and the construction of open channels can be used effectively and cheaply to move water away from the source and point of collection for human populations. Livestock watering facilities should be situated downstream of any further water extraction for human consumption.

Contamination of human water supply by livestock - animals should be stopped from physically entering the water by careful use of troughs, bund walls, parapets, and hard standing areas. Similarly, hard standing areas should be very well-drained to ensure livestock are not made to wade through increasingly thick layers of wet mud.

Water Quality and Safety

It is important to ensure that water is basically free of specific water-borne diseases, parasites or vectors and is not contaminated with toxic chemicals. However, water quality for livestock is generally much less of a critical issue than for human consumption (for example, there is no livestock equivalent to a water-borne disease such as cholera, which presents a key water quality challenge for human water supplies). This may offer opportunities for reducing conflict with human demands if high-quality water sources are limited. Poorer quality water from rivers or standing lake water that cannot feasibly or economically be purified for human consumption may be reserved for use by livestock.

Storage, and in particular enclosed storage, flocculation using local products such as moringa, sedimentation and settlement are all cheap and simple forms of treatment that can be applied to water for livestock.

An understanding of turbidity and its measurement should be required of any practitioner working in the field. The ability to measure and compare samples will be useful to even an untrained person.

Local Equity and Management Issues

The access of women, children and vulnerable groups to water should be protected by the careful management of water sources and distribution points. As the primary users and collectors of water, the involvement of women and vulnerable groups in the design of watering facilities and their management should be sought from the earliest stages. Their active participation in the management of facilities after completion should also be encouraged. The use of participatory methods will help to ensure the views of the poor, illiterate and otherwise vulnerable can be incorporated into the design of systems.

Boreholes as well as shallow and deep wells are usually managed by local (often customary) institutional arrangements, or by private owners or managers of the water source. The rehabilitation of existing water ources or the establishment of new sources should take into account these management systems and fit into them in order to promote sustainable and equitable water use. The management of water distribution in water trucking activities can also build on local water management systems to help ensure equitable distribution and access within communities. Where IDP camp residents need access to water for their livestock and must share resources with the host community, negotiations beforehand can help to avoid potential conflict. Establishing clear and equitable management systems for water sources is also important for the longer term - into the recovery phase and beyond; experience has shown that unless these issues are considered at the beginning of the intervention, water sources may fall into disrepair a short time after the end of the emergency.

Watering facilities should be well designed and efficiently managed to avoid unnecessary congestion, inequitable distribution of resources and operation at night or other dangerous periods. Clear guidelines should be set, outlining when and at what times of the day, watering facilities will be operational and how much these services will cost, if indeed charges are to be applied at all.

Long-term management and maintenance

The planning and provision of regular maintenance should be sufficient to keep facilities operational throughout the emergency period and beyond, and the body assigned for the management of water sup- plies whether government, agency or community body should be accountable to the users.

A key aspect of maintaining water facilities is ensuring adequate funding for capital expenditure and day to day running costs. In setting water tariffs, costs should be affordable, livestock owners must be willing to pay and there must be a system of penalties for not paying. Vulnerable groups and the poorest should be consulted prior to implementing tariffs.

Environmental Issues

The negative impact of displaced people and their livestock on the natural environment should be minimised as follows:

Waiting times and congestion around water points should be minimised to avoid degradation and destruction of vegetation in the area around the water points. The proper design and location of water distribution facilities will mitigate congestion and unnecessary waiting.

Water points should be kept clean and free from flies and pests, including vectors of diseases, through appropriate design and management. Minimal charges for water should provide adequate incentives for the proper management and day-to-day maintenance and cleaning of water points. Proposals should be discussed before beginning work on construction.

Watering facilities for livestock should be placed downstream of any extraction points for human consumption. Faecal matter from livestock should be kept away from entering secondary watercourses or entering into groundwater sources. Utilisation of dung for fuel, biogas, and/or fertiliser should be encouraged.

Water Trucking

In some situations the trucking of water may be the only viable approach to ensuring water supply for pastoral livestock during drought. The approach is relatively expensive and has limited sustainability.

Any plan for water trucking should be fully costed and matched against the overall benefit expected for livestock owners including the timeframe and eventual exit strategy.

Management Issues

Staff management and supervision - successful trucking operations require consistent and sustained staff inputs. This includes a need for competent, experienced management and supervision. However, it is also important to ensure that drivers and assistants are kept motivated through proper reimbursement and careful attention to other needs including subsistence allowances and personal security considerations.

Monitoring deliveries - with capable and reliable supervisory staff working in collaboration with community leaders it is possible to ensure the correct number and amount of deliveries. Without careful monitoring, it is quick and easy for fraudulent operators to offload supplies along the route and to claim payment for non-delivery unless beneficiaries are made aware of what they are supposed to receive.

Contracts - clearly worded contracts should be written and signed between agencies and trucking contractors, specifying delivery targets and mutually acceptable methods for measuring deliveries. Checks should also be made to ensure that no detrimental effects are felt by existing populations due to the withdrawal of trucking facilities from their usual work.

Design issues

Selection of water sources - use of the selected source/s should be approved by all relevant authorities and user groups. Seek local advice regarding the ownership and rights to any proposed water source. Potential water sources often include urban supplies belonging to private companies, schools, churches etc. Should water be extracted from surface water sources such as rivers and lakes then additional arrangements will be necessary for the loading of trucks.

Trucking routes - should be surveyed and properly assessed to avoid problems with degradation over time and periods of inclement weather. Before entering into trucking agreements, routes should be identified and surveyed including all bridges, fords and other obstacles. The type and suitability of road surfaces should be assessed noting any possible difficulties due to future inclement weather or gradual degradation of surfaces. The cost of, and methods for dealing with these problems and mitigating against future disruption should be considered as early as possible Selection and maintenance of fleet and equipment - use only appropriate means of transport, taking into account loading and bearing capacities of trucks and various road surfaces. Consider whether articulated or rigid trucks should be employed. Can flatbed trucks be fitted with secured rigid or flexible tanks? Are tractor-trailers more appropriate? Check what each tanker has been transporting in the past and ensure that proper cleaning is undertaken. Qualified mechanics and reliable supplies of uncontaminated fuel need to be available throughout the duration of the trucking operation. This includes any material needed to operate and maintain pumps and containers/delivery equipment. Major issues to consider are:

Cost and availability of fuel - ideally, it should be possible for drivers to refuel without making major detours away from the trucking route. This may require fuel to be brought in separately, adding to the logistical complications of the operation. It may also be a consideration in the original selection of water sources.

Spare parts - should be readily obtainable. Simple, locally made equipment that is easily repairable is to be preferred to hi-tech or imported solutions.

These issues - particularly those relating to maintenance - may affect the decision regarding the type of transport that will be used by the trucking operation e.g., trucks or tractors and trailers with bowsers or bladder tanks.

Distribution Issues

In addition to the water distribution issues detailed in section 5.3.3 above, the effective distribution of water from tankers will require:

- Easy access and turn-around space for vehicles
- Good drainage
- Adequate storage
- Easy offloading into communal facilities (i.e. not into individual containers)

It is important to note that initial deliveries should be extremely well managed and well thought out to ensure the safety of agency staff and beneficiaries alike. There may be a great deal of anxiety present among the beneficiaries whose livestock may already be highly stressed and dehydrating fast. These people/animals will be impatient to receive water. It is important to let people know that additional, regular supplies will be arriving after initial deliveries have been made. If possible try to build up ad- equate stocks of water quickly.

Relocation of livestock is often implemented as part of the response to an emergency situation (either as part of the indigenous response or coordinated by external agencies). Where this is occurring, trucking of water may be required to support the migration. This situation will add considerably to the already complex logistics of water trucking.

Monitoring and Evaluation

Monitoring and evaluation systems should be established to ensure that the provision of water is implemented effectively and has a positive impact on livelihoods. The system should be established before implementation begins to enable the correction and adjustment of activities and the collection of data to facilitate learning and impact assessment.

In common with other services, the provision of water can be measured using five key indicators viz. accessibility, availability, affordability, acceptance and quality. These indicators apply to both relief and development interventions, and can be measured using a mix of conventional and participatory methods.

Policy Implications

The need to provide emergency water supplies to livestock, particularly during drought, is indicative of the inadequate long-term development and management of water resources in pastoralist areas. Water development policy needs to take account of the need for better use of water resources while also recognizing the advantages of mobile pastoral

livestock production systems and the environmental damage in Kenya caused by the inappropriate provision of water. It is increasingly recognized that inappropriate construction of boreholes, both in terms of location and number, disrupts livestock movements and grazing management.

Experiences of water development for livestock indicate that pastoralists should be involved in the initial analysis of water issues, including predicting the positive and negative impacts of new water sources, and how new facilities will be sustained and managed in the long term. Part of this participatory analysis relates to broader natural resource management issues such as dry season grazing practices and areas that traditionally, are preserved for dry season use.

Daily Water Requirements for Livestock

To estimate the approximate needs of the livestock population in the area, figures in Table 2.61 for daily water requirements may serve as a rough guide:

TABLE 2.61. DAILY WATER REQUIREMENTS FOR LIVESTOCK

Type of Livestock	Average water requirement (litres)	Frequency of drinking
Camels	60–80	Every 4 or 5 days or longer
Cattle	30–40	Every 1 to 3 days
Equines (donkeys, mules, horses)	15–25	1 or 2 days
Sheep	4–5	1 or 2 days
Goats	4–5	Preferably once a day
Pigs	0.5–2.5	Preferably once a day
Poultry	0.05–0.15	At least once a day

Table 2.62 gives an indication of the discharge rate from traditional and modern wells and boreholes, to show the approximate number of livestock each can serve:

Table 2.62. Water discharge from traditional and modern wells and boreholes

Water source	litres/hour	Water discharge Max hours/day	Total litres/day	Number Cattle*	of animals Sheep/ goats
Traditional well	1,000	7	7,000	280	1,400
Modern well	5,000	15	75,000	3,000	15,000
Borehole	>20,000	20	400,000	16,000	80,000

* Based on an average consumption of 25 litres/day
+ Based on an average consumption of 5 litres/day

Further Reading

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2.5 MODULE 5

RANGELANDS IMPROVEMENT AND REHABILITATION

Rangelands are lands on which the vegetation is predominantly grasses, grass-like plants, forbs or shrubs and is managed as a natural ecosystem. Rangelands can include annual and perennial grasslands, shrub and dry woodlands, savannah and tundra. These areas provide many goods and ecosystem services of vital importance to local communities hence sustenance of livelihoods.

Most of rangelands are becoming degraded as a result of human and climate induced factors. Over 33% of the global land is degraded.Land degradation and desertification is more severe in sub-Saharan Africa, whereby it is estimated that 75% of Africa's drylands are affected by moderate to high degree of land degradation . Land degradation is the reduction in the capacity of the land to provide ecosystem goods and services and guarantee or assure its functions over a period of time for its beneficiaries . In Kenya, it is estimated that over 30% of the country is affected by severe to very severe land degradation .

With respect to natural pastures, which are the basic feed resources for livestock in the ASALs, degradation is a process that involves various attributes. These include the net loss of vegetation beacause of heavy grazing without sufficient time to rest, reduction in palatable forage species, decrease in palatable perennial grasses, increase in annual plants and species rarity. Bush encroachment and weed invasion as well as increase in invasive species is another form of challenge in the ASALs thus bringing about rangelands degradation.

In the rangelands, land and pasture degradation is a major challenge to household food security due to its impacts on livestock feed availability. Community involvement is key in most cases while addressing land and natural pasture degradation, which ensures they access benefits from their efforts of restoring and protecting the environment. The overall aim in this module is to provide guidelines on the rehabilitation and restoration of denuded/degraded rangelands to its natural state through approaches that aim to increase vegetation cover, biodiversity and create resilient environments.

This module will be covered under the following sub-modules:

- Range reseeding and pasture seed production
- Grazing enclosures and grazing management
- Holistic planned grazing for range improvement
- Invasive species: management and control
- Rangeland infrastructure development

2.5.1 SUB-MODULE 1: RANGE RESEEDING AND PASTURE SEED PRODUCTION

Range reseeding is the introduction of grass, legume or other selected seeds to replenish depleted soil seed banks while providing forage for livestock. With changing land uses, reduction in grazing areas, frequent droughts and overgrazing, opportunities for self-seeding of the natural vegetation are reduced. This leads to the depletion of the soil seed banks in the land. Reseeding with appropriate species, particularly perennial and self-sustaining species has been promoted as an option for range rehabilitation with different goals. Some of these include to increase plant diversity, improved forage quantity or quality for livestock, tall grass for structural diversity, plants producing large or abundant seed for wildlife, native legumes and forbs and deep-rooting species for soil stabilisation in disturbed areas. Various successes have been reported especially where native species have been used.

A decision to reseed depends heavily on individual judgement. For areas where more than 10% of vegetation is native, natural succession alone can suffice. Understanding the causes of the degradation in an area guides on decision-making on reseeding or approach to use for rehabilitation. Reseeding alone may not be adequate, Degraded lands may never return to their historical state because of soil loss and/or other conditions.

Steps to successful reseeding and pasture seed production

Understanding the site

- Consider the weather/climate and site conditions. Weather conditions include rainfall amount and distribution per annum and temperature ranges. Site conditions incorporate soil condition, drainage & salinity, the slope (affect land preparation e.g. need for terracing), factors which affect establishment.
- Important for species selection – each species has different tolerance limits for the above characteristics including soil types, soil moisture among others.

Species selection

Perennials (plants that live for more than two years) are preferred to short lived annuals in range restoration where conditions allow

Some factors to be considered during species selection for range rehabilitation:

- Adaptation to local soil and climatic conditions such as drought tolerance/moisture tolerance
- Species' compatibility; - e.g. complementarity with available vegetation, shade tolerance in relatively wooded/bushed areas or silvo-pastoral system
- Intended utilisation method of the restored area e.g. grazing or machine harvesting, seed production, soil conservation e.tc
- Potential higher biomass yield, high seed production, species persistence and tolerance to grazing for sustainable use
- Community preference with regards to utilisation type
- Species mixtures are preferable to a single species because each species has different strengths and weaknesses and a combination of species has much greater biological resiliency to grazing, fire, insects, drought, prolonged cold, excess moisture, etc., than a monoculture. Legumes can be incorporated in grass mixtures.

Examples of grasses and legume species in Kenya include: -

For rain-fed reseeding: Foxtail grass (*Cenchrus ciliaris*), Bushrye (*Enteropogon macrostachyus*), Maasai lovegrass (*Eragrostis superba*), Horsetail grass (*Chloris roxburghiana)*, Guineagrass (*Panicum maximum*), Red oats (*Themeda triandra*), *(Bothriochloa insculpta)*, finger grass (*Digitaria* species), coloured guinea grass (*Panicum coloratum*) amongst others.

Cenchrus ciliaris (left) and *Eragrostis superba* (right)

For irrigated reseeding and pasture establishment: Sudan grass, Brachiaria varieties, Chloris gayana varieties (Boma Rhodes),

- Herbaceous legume species eg. Indigofera cliffordiana, I. spinosa, Neonotonia wightii, clitoria ternatea.
- Woody legume species including Tinospora caffra, Melia volkensii, Leucaena leucocephala

Land preparation

Land degradation involves the preparation of a site for establishment of vegetation. This helps in loosening the soil surface for ease of penetration of roots and prevents grass seed from being blown away by wind. It also enables better

infiltration of rainwater by creating microsites for water hence enhances soil moisture availability and conservation. Land preparation also aids in removal of weeds to reduce plant competition and give the target plants a head start after planting. Steps of land preparation include

- Remove bush or other invasive species if present in the farm. Can be mechanically done or manually using handheld tools.
- Plough the land using either the tractor for faster land preparation or the ox-plough then do the harrowing. Sometimes the level of preparation depends on the target planting method e.g. ox-ploughing commonly used in planting in furrows; over sowing requires minimal tillage if any e.g. ox-sloughing, harrowing or manual digging.
- Hand tools like hoes may also be used for small-scale structures like micro catchments and range pits
- Other examples of land preparation involve construction of water harvesting structures such as Kiboko range pits (half-moons), zai pits, tied ridges, etc) and planting vegetation along the structures. Use of water harvesting structures does not require ploughing.

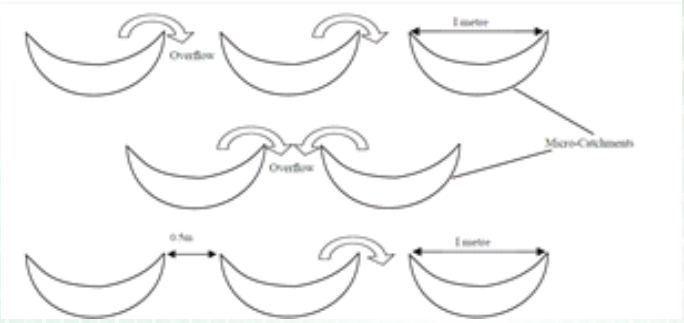

Diagram of Kiboko range pits for water harvesting (Photo J. Ayemba)

Site description information is necessary during land preparation. This includes information about the slope, terrain or erosion potential which inform what the ploughing method, erosion control measures e.g. terracing, leaving unploughed strips to break water flow, among others.

Planting

Proper timing of the seasons during planting is important for successful establishment. Normally it is advisable to plant just before the rains for rain fed reseeding. Seeding should take place when the soil contains enough moisture for seeds to germinate and plants to become established. Two methods of planting are commonly used for fodder and forages

Drilling into furrows/direct seeding. There are recommended depths for different species depending on the seed size and soil texture that are important in determining sowing depth - the smaller seed and the heavier the soil, the shallower the planting depth. Generally, planting depths range from 0-2cm for grasses. While there are some large-seeded forage species with 5,000-50,000 seeds/kg, most forages have small to minute seeds (100,000 to >10 million seeds/kg). Thus, seeds should not be buried deeply since initial vigour is not sufficient to push through a heavy cap of soil.

Broadcasting: The seeds are spread in the field while considering the direction of the wind for even distribution. It should be considered that about 50% of plants fail to germinate hence the need to double the seed rate.

Other planting methods includes include:

- Over sowing (reseeding into natural existing grassland, commonly non-ploughable area)
- Under sowing (establishment of a pasture under a cover crop).
- Planting using vegetative material/splits (common for species without seeds) – transplanting from one area to another.
- Aerial planting – for larger expansive areas but this has the disadvantage of many seed losses.
- Use of animal/grazing management to seed the area (e.g Holistic management). In this case, animals ingest grass seeds and deposit in other areas in the form of dung containing viable seeds.

Consider the recommended seed rate per species/variety. Commonly 5kg/ha for range grasses and is adjusted for percent viability. Other grasses and species have recommended rates and spacing

Weed Management

It is natural for weeds to germinate together with planted grasses and legumes hence the need for weed management. This is recommended for good crop establishment. Different types of weeds affect pastures including annual and perennial weeds. Eventually, these affect established pastures necessitating management interventions. There are different methods of weed control and management in rehabilitated lands.

Methods of weed control include

- Chemical control (pre-planting, pre-emergence, and post-emergence chemicals available in recommended stockists and agrovets)
- Manual weed control using hand tools by digging out unwanted plants
- Crop rotations and crop competition – utilization of different crops on same farm
- Biological control – use of biological control agents i.e. the natural enemies of the target crop.
- Use of fire (good for large scale grazing areas and for control of bush encroachment in grazing lands).
- Integrated approaches - combination of two or more of these methods.

Soil Fertility Management

Fertiliser or manure use during planting is used to correct nutrient deficiencies and enhance crop production. Phosphate based fertilisers or farmyard manure is used at planting to promote strong root development. The recommended fertiliser and manure rates are dependent on the crop and soil conditions and mostly after a soil nutrient test.

Top dressing is recommended during plant growth, particularly in the subsequent seasons after the establishment period. Nitrogen is one of the most important nutrients for grass seed and biomass production. However, consider the age of the crop, time of the year and climatic conditions at the time of fertilizer N application.

Manure being readily available in the dryland regions is normally highly recommended because it does less harm to the environment.

Management and Utilisation of Rehabilitated Lands

- Once rehabilitated, the area could be used by directly grazing or by harvesting the forages for utilisation outside the area. Controlled grazing is practised where animals are grazed.
- Consider principles of grazing management including proper timing of grazing and rest intervals to allow for plant regrowth between grazing events and prevent overgrazing.
- If the plants can be pulled out easily by hand, then it is recommended not to graze but to give it an extra season of establishment.
- Grazing frequency and intensity - how frequent and much forage stubble or leaf area is left on the plant at the end of the grazing activity should be taken into account.
- Shorter grazing periods ensure controlled grazing intensity with higher benefits to both the animals and the plants. Longer grazing results in grazing on new plant re-growth and reduced harvesting efficiency by the animal hence lower animal performance.
- Adjust stocking rate (How much is utilised) to match with the carrying capacity (the amount of feed available).
- Monitoring of the pastures: The principle of monitoring is important in ensuring other principles of grazing management are adhered to. Monitoring is done for regrowth, trends for species composition including checking for invasive species and other weeds.

Harvesting of Seed for Reseeding

Once mature, seeds can be harvested and taken for storage and future reseeding elsewhere. Key points in seed harvesting that needs consideration include

Timing: Timing to identify mature seed heads (the colour of seed heads varies with species). A golden-brown colour or appearance of the seed heads is the major indicator of the time when the seed is ready to harvest. Additionally, if seeds are easily dislodged from the plant, they are ready for harvesting. Harvesting should be done when most (over 60%) of the seed heads have attained this colour

Timing is also important to avoid delays and loss of seed through shedding that is common especially with forage grasses and legumes.

Seed weight, hardness and moisture content are other indicators of seed readiness for harvesting. Hardness is checked by pressing the seed with the fingers or between teeth.

Harvesting method. For grasses, there are **two main methods of harvesting** seed namely

- A) stripping - Stripping involves removing only the seeds from the seed head or inflorescence
- B) Cutting with stalk - cutting with stalk involves cutting the seed head together with its stalk and the last leaf. This will ensure continued maturing of the seeds post-harvest.


Seed harvesting: Stripping method (left) and Cutting with stalk (right)

Pasture Seed Processing

Seed processing involves threshing, cleaning and sorting to remove foreign materials undesirable seed, drying, packaging and labelling. Additional steps like sorting/grading to improve quality of the seed and protecting the seed from damage by pests and fungal infections is done for the seed of some grass and legume species.

Threshing is the process of separating seeds from panicles and straw. It is done by beating with sticks to dislodge the florets/seeds, particularly for the seed harvested through cutting with stalk.

Threshing of grass seed

- Different types of seeds will dry at different rates depending on the prevailing weather conditions such as temperature, relative humidity and wind.
- Harvested seed in the tropics usually have a high moisture content of up to 40-70%. Therefore, they must be dried to safe moisture levels (8-12%) to reduce physiological activity. Fungi easily damages both grass and legume seed that have high moisture content.
- Sun drying or drying under a shade is recommended depending on initial seed moisture content. The seed

should be turned regularly for proper aeration.

Packaging and Storage

Packaging is important because it protects the seed from physical, climate and biological damage. Ensure seeds are well dried. Airtight containers are the best for long term storage. Examples of package and storage containers include:

- Tailor-made white woollen /cotton bags
- Woven or synthetic sacks
- Prefabricated aluminium tins/containers
- Brown paper bags
- High-density polythene paper bags
- Metallic containers and plastic containers

Once the above steps have been taken into account, the harvested seed and plant materials can be taken to other areas for expansion of other rehabilitated areas.

2.5.2 SUB-MODULE 2: GRAZING MANAGEMENT

Enclosures (or sometimes referred to as exclosures) are areas in rangelands, closed-off from any interference from both humans and animals with the aim of promoting the natural regeneration of plants and reducing land degradation on formerly degraded grazing land. It is one of the most effective techniques for restoring degraded rangelands by modifying the composition, abundance, and diversity of species.

The protection period or rest time allows vegetation to regenerate and produce seed for harvesting or self-seeding. This allows for natural regeneration hence improving plant species composition, abundance and diversity among other benefits. It can be done together with reseeding and other rehabilitation structures to enhance the outcome of the rehabilitation. Scientific and indigenous knowledge should be included into rangeland enclosure management. Enclosure may involve physically fencing off land parcels for private or commercial use using live fences or modern fences

Traditional enclosures using indigenous tree branches

Preparation of Enclosures

Involves identifying and enclosing a designated area that one needs to protect. The size is dependent on the capacity of the farmer/livestock keepers or community. Normally, partition is commonly done using natural dead plant twigs/ thorns and branches in the pastoral areas. A permanent fence by use of electric fences, barbed wire or poles can be erected where resources allow.

Benefits of Having Enclosures

With the exclusion of animals, several benefits are accrued from enclosures and enclosures. These include: -

- Increased quantity and quality of pastures
- Reduced livestock migration

- Easier livestock management
- Allows for proper land management e.g. controlled grazing
- Allows for preservation of pastures for dry season grazing hence reduced animal losses
- Improved livestock health and productivity
- Increased plant diversity
- Increased ecosystem/environmental services

.Grazing Management

Grazing management is organizing livestock to make the best use of the pastures grown or managing the frequency and intensity that livestock graze natural or established pastures. This is an important factor in management of soils, water and nutrients to minimize incidences of rangeland degradation. It involves the following key issues:

- Understanding grazing animals and their management
- Stocking rates and carrying capacity
- Regulation of grazing - designating wet and dry season grazing areas
- Intensity and frequency of grazing - short duration grazing alternated with long rest periods
- Controlled grazing, rotational grazing
- Pastures and fodder conservation
- Grazing ban near water points in wet seasons.

2.5.3 SUB-MODULE 3: HOLISTIC PLANNED GRAZING FOR RANGE IMPROVEMENT

This is a concept developed in the 1960s by a range scientist, Allan Savory. It is a strategy for regenerating degraded areas and their livelihoods while utilising ecologically, socially, and economically sound activities. It is similar to rotational grazing but recognizes four ecosystem processes, namely, water cycle, nutrient cycle, energy flow, and community dynamics. It is cost-effective, uses a nature-based solution, and is highly scalable. It is sustainable because it increases land productivity, livestock stocking rates while ensuring the wellbeing of the community.

It is based on the hypothesis that domestic livestock can substitute for wild animal herds that previously utilised the natural vegetation sustainably. These natural herds of wildlife grazed, defecated, stomped, and salivated as they moved around, building soil and deepening plant roots.

Approaches and Principles of holistic management

- Understand the environment you are managing
- Animal impact as a tool - livestock can improve land health
- Grazing as a tool
- Seasonal planning - time is key
- Big picture consideration – nature functions as a whole- wildlife, livestock, plants, soils, people e.t.c

Eight commonly used tools are money/labour, human creativity, grazing, animal impact, fire, rest, living organisms, and technical knowledge

- Set a goal for what one wants the land to look like (covered ground, good healthy plants, many vegetation types, rivers flowing and others), and how the community wants to work together (who is involved, their roles, how will they organise themselves, plus aothers)
- Control use of the area
- Divide the area into grazing blocks (as many as possible).
- Only one block to be used by all herds at any one time.
- Calculate the number of days the herds will spend in each block according to:
- Available forage in each block (for dry season)
- How much land is to be grazed & how many times (for wet season)
- Decide the sequence the herds will move through the blocks.
- If possible, combine as many livestock types together.
- Graze a different section of the used block each day.
- Do not come back into a block before the grass has recovered.

- Monitor one's animals and soil impact daily, monitor one's land every 6-12 months

Benefits of Holistic Management

- Increased ground cover
- Increased water infiltration and retention of soil moisture in the soil
- Increased organic matter
- Reducing erosion
- Improved wildlife habitat and healing the environment

Critique of holistic planned grazing

The principle does stand without its own critiques though. It is alleged and commonly known that many animals congregating in one area lead to a lot of degradation. Soils in arid and semi-arid areas are known to be fragile and the rainfall highly variable. As a result, there is a possibility that some of the ecological processes may not work effectively as anticipated.

2.5.4 SUB-MODULE 4: INVASIVE SPECIES: MANAGEMENT AND CONTROL

Invasive plants: Plants that have, or are likely to spread into native or minimally managed systems and cause economic or environmental harm by developing self-sustaining populations and becoming dominant or disruptive to those systems

Invasive species are an emerging problem in the drylands creating disasters affecting communities. Livestock keepers are directly affected by the invasion and continued spread. Many regions in the dryland of Kenya are currently under the threat of invasive species. There is a need to mitigate the impacts of invasive species in the drylands to safeguard and build the resilience of the communities affected.

Examples of these species in Kenya include: - Ipomoea species, *Prosopis juliflora* (Mesquite), *Acacia reficiens*, Prickly pear (*Opuntia ficus*), water fern, Water hyacinth, *Acacia polyacantha, Lantana camara* and *Parthenium hysterophorus* (parthenium weed). *Acacia reficiens* is a very aggressive species in the northern parts of the country while Opuntia spp is found mostly in the arid and semi-arid zones of the country. *Prosopis Juliflora* has invaded thousands of acres in east Africa while *Ipomoea kituensis* is currently ravaging many parts of southern Kenya. *Parthenium hysterophorus* is another species fast spreading in central Kenya including Kajiado and Naivasha regions. All these species have been noted to be a menace in the environment as well as the ecosystems in which they are found affecting livelihoods.

Origin, Spread, and Distribution of invasive species

Invasive species are either introduced intentionally or accidentally. Most originate long distances from the point of introduction. For instance, the invasive species mesquite (*Prosopis juliflora)*, native to South America, was intentionally introduced to combat desertification and tackle energy needs in the drylands of Kenya by the Government through the National Irrigation Board (NIB). Origins of other invasive species and the current spread or distribution are however unknown due to limited studies on this topic. Invasive plants are mainly distributed in the semi-arid and arid zones of the country. These are areas where these species find it easy to establish and colonise mainly due to favourable environmental conditions. Their invasion and spread is however mostly driven by land use changes and climate change. The plants are mostly spread by different pathways including animals, birds, people, tourism, agriculture inputs, water along roads, among other factors.

Features of invasive species and invaded environments

- Invasive species characteristics - High adaptability, tolerance to a variety of environmental attributes, rapid maturation, High reproductive output, seeds have a high percent germination, ability to colonise from a single propagule, Effective dispersal mechanisms, Aggressive behaviour and competitive ability, have longer photosynthetic periods
- Invaded environments - similarity to origin, disturbed environments, lower biodiversity, availability of secondary pathways for invasion

Ipomoea kituensis invasion in Kajiado County

Mesquite plant (*Prosopis juliflora*) invasion in Garissa County

Impacts of Invasive Effects of Invasive Species

The effects of invasive species on the environment and communities are wide-ranging. These can be categorised into environmental, economic, and social effects.

Environmental Effects

- Displacing all herbaceous and grass species wherever they are growing e.g Prosopis juliflora and Ipomoea kituensis. As a result, livestock will suffer due to unavailability of forage.
- Modification of the hydrological cycle
- Breeding ground for pests and diseases.

Economic effects

- Damage to goods and infrastructure - roads and paths thereby restricting movements and displacing infrastructure
- Land which used to be used for cropping and forage production for livestock has hence been taken over by invasive species hence reduced productivity.
- Generally, economic losses effects are manifested in control costs and reduced productivity.
- Social Effects
- Invasive effects normally lead to losses including loss of life,
- Increased poverty, and deprived livelihoods.
- Impaired access to food, shelter, health, security and social interaction.

Control Techniques of Invasive Species

Different control techniques have been suggested for the control and management of invasive species. Some of these include manual control, chemical, biological control, and integrated approaches but the key remains the application

of rangeland management principles to prevent invasion. The most common practice utilised is the manual control where communities are involved aided by investments from government and private sector.

Principles

- Control when first seen - uprooting manually
- Control before flowering or before seed setting
- Plant other species after removal - adapted species – grasses, legumes and appropriate woody species
- Capacity building on control, management, utilisation
- Education and awareness - shows and exhibitions

Use and Benefits of Invasive Species

Not only do invasive species contribute negatively to the environment, but they also provide several goods and services to communities living in the drylands. However, their relative values depend on what is displaced. Some of the benefits include the

- Provision of firewood and briquettes
- Timber for construction and building materials
- Compost making
- Barrier plants and medicines
- Contribution to soil stability
- Provision of feed for livestock - Acacia, Opuntia, and Prosopis pods are used as feed by many livestock species in the drylands hence a crucial source of protein.
- Invasive species also provide crucial ecosystem services
- Habitat and shelter for wildlife and livestock
- Environmental services such as carbon storage and sequestration
- Water filtration
- Soil stabilisation, among others.

The key element, therefore, remains to manage the invasive species to levels where the environment and people living in the areas where they are found do not suffer irreversibly when removed.

2.5.5 SUB-MODULE 5: RANGELAND INFRASTRUCTURE DEVELOPMENT

Infrastructures play an important role in the development of the rangelands for livestock production. These include water infrastructure (boreholes, water pans, subsurface dams and improved shallow wells), Sale and auction yards, holding grounds, dips and spray races, loading ramps and collecting yards, roads and stock routes, among others. One of the most common and important infrastructures for livestock production in the rangelands is Water infrastructure.

Water Infrastructure:

The biggest need in the rangeland for livestock after feed is water, therefore understanding daily livestock watering needs is key when designing a livestock watering system. Proper planning for the financing and development of water sources, and day to day water service provision (for domestic/livestock) is critical and requires time and effort to make sure that the intervention and support given is appropriate, targeted and demand driven in the long term.

For a rangeland to be self-sustaining, the cost of development of and maintenance of infrastructures must be borne by the users.

Considerations for Securing Water Developments in Drylands

When selecting a water infrastructure, greater importance needs to be given to technical, governance and ecological considerations of range management, compared to a focus on the individual water technologies. These are: -

The Pasture-water balance

- Understand local dynamics including natural resources and seasonal livestock grazing patterns. The number of water points and their distance from natural pastures will determine the frequency and distance livestock have to trek to reach water and pasture
- Poorly sited infrastructure leads to degradation due to settlements and congregation
- Seasonal water sources are preferable than permanent ones

Technical characteristics of the water point

- Affordability to construct, maintain and sustain
- Depends on whether the water is for domestic or livestock use
- Consider gender dynamics – since women are the ones who collect water most of the time
- Consider factors such as the number and type of livestock, domestic use requirements, livestock grazing patterns, the type and effectiveness of management, and the technical capacity
- Technology should be sustainable
- Should be appropriate such that water point managers can understand and use themselves

Governance system for managing access to water

- There should be control over access by community and visitors to water – this will determine stocking rates on pastures in an area
- Prioritization of water for domestic versus livestock use as the dry season progresses and water becomes increasingly scarce
- Community-managed associations (or WUAs) should be inclusive and representative of different social groups, including women, the poor and marginalized.
- Rules for equitable access to water, for example for women and other vulnerable social groups must be present.
- Visitors seeking water will need to negotiate access, through the principle of reciprocity.
- Conflict may arise in the absence of clear governance rules that are followed by all user

Good Practice Principles for Development of Water Infrastructure

There are four broad principles;

Planning. Water development needs to be part and parcel of natural resource management while recognizing the way that water access and use affects how the broader natural resource base is used and managed. One needs to understand the broader natural resource base and livestock grazing patterns/seasonal movements

Understand local contexts and dynamics, including the social, economic, political, legal and cultural aspects of a given location. Research into the local context should include, but not be limited to: all the potential water resource users (e.g. downstream and upstream users along rivers); water access patterns; water needs/demand; particular concerns relevant to the area—including conflict over resources; customary institutions and their role in water/resources management; interactions with other governance institutions and stakeholders; and gender considerations. A comprehensive stakeholder analysis should be conducted at the local level to enhance the process. Planners must engage with all the local groups that represent the different resource users in the area, including representatives of customary institutions, women, vulnerable groups and non-local pastoral

Design. Paying attention in the design phase to the rehabilitation of existing systems should be given priority, particularly in the context of emergency interventions when the project lifecycle is limited. During the design phase the following are of importance.

- Identify the existing water points first and explore options for their rehabilitation by upgrading the water supply system before designing new ones.
- Identify why the existing water systems are non-functional or performing poorly as a first step. Improving the performance of what is already there is not only cost effective but researching the existing water supply system can help identify problems and the level of user responsibility. Future operation and maintenance will need to be a continuous process and mainly the responsibility of the users.
- Evaluate the need for and potential impacts of introducing new water points and identify remedial measures

to tackle negative impacts. This can be carried out through an Environmental and Social Impact Assessment process.

- Select the water development option based on choice of technology, cost considerations as well as on the expressed needs and capacity of the community. A technical feasibility study and a cost-benefit analysis can identify certain choices, but the community should make the final design decision.
- Planners should explain the technological options available and help communities—through a process of dialogue and knowledge sharing—to select the most suitable technology and design that will satisfy their local needs.
- The use of traditional systems should be encouraged—the designs for which and local materials and construction know-how are already available.
- The technical capacity that will be required to operate and maintain the water points, as well as spare parts availability. In remote areas, access to external technical assistance, construction materials and spare parts may be very limited.
- Technologies which do not encourage settlement, and which adequately space water points to alleviate pressure on any single water point, must be selected for rangelands.
- Integrate water development design with other pastoral development interventions. Water development should be linked with efforts to improve access to markets, rangeland rehabilitation, etc. to address vulnerability and poverty effectively over the long-term—supporting and improving livelihoods.
- Promote meaningful engagement with communities throughout the project identification and planning phases. The intervention should promote the use of participatory/consultative methods. Using participatory methods will enable planners to understand and benefit from local knowledge systems and allow dialogue between communities and planners on the most suitable type, placement and size of water points.

Implementation. Ensure constructed water structures are of good quality by focusing on proper design and construction. Community/local capacity should be developed in the construction of the water sources for sustainability.

Promote the contribution of cash and/or labour in-kind in the construction or rehabilitation of water points. This reduces project costs as well as instils a sense of ownership, enhances community commitment to maintaining the water point, and ensures that it is sustained beyond the lifetime of the project. Local contribution is important, should be realistic and should be accompanied by effective community mobilisation.

Strengthen the capacity of water users in management, operation and maintenance. Communities should be assisted in establishing water management committees (or variations thereof), which include representatives of all groups with a stake in the development. The committees that help and manage the water interventions should be built upon existing customary resource management systems. These customary systems often provide a tried and tested context and culturally appropriate approach to water management, which can help diffuse/avoid conflicts over water. Ensuring a combination of formal management committees and customary institutions is recommended.

Provide training to local community members in construction, management and maintenance to embed capacity at the local level. Develop a training curriculum with approaches appropriate to the target community, guided by a training needs assessment. Providing quality training to build community capacity and properly prepare community representatives to manage their system is essential for a sustainable rural water supply.

Sustainability. Continue to assist communities to manage water systems for some time after completion of the project. Adequate follow-up and mentoring may be required for some time. The community may engage private entities like a local entrepreneur, a CBO/NGO, women or youth groups to run the water supply on their behalf to ensure sustainability. However, the plight of the vulnerable groups should also be considered.

Undertake knowledge sharing, exchange and cross learning among implementing partners and relevant government agencies. Exchange visits by communities, to see properly working and successfully managed water supplies, is an important way to demonstrate what is possible, and to raise community expectations. This will enhance the adoption of good practices in the region.

Water sector development actors need to agree on common approaches to development/financing, which avoid undermining good governance. Misguided donations of equipment and spare parts can promote the un-sustainability of community water projects. Often such donations, although well meaning, promote dependency by freely bailing out communities that have failed to manage their water supplies well, thus rewarding mismanagement. Relief should

be linked to development i.e. by adopting a long-term livelihoods approach to humanitarian interventions.

Types of Water Infrastructure

Boreholes: they are deep, narrow wells that tap into naturally occurring underground water. A high efficiency pump is installed to extract the water from the permeable rock below for use.

Sand Dams/subsurface Dams: Sand dams are reservoirs created when a short wall is constructed across a sand river allowing the storage of both water and sand carried by the flood waters.

Shallow Wells: Less than 20m deep with low water yields

Water Pans: These are small reservoirs, about 1 m to 3 m deep, usually dug off-stream or in open areas, and having raised and compacted banks. They are constructed to collect and store runoff water from various surfaces including from hillsides, roads, rocky areas and open rangeland.

Charco Dams: These are really small excavated pans or ponds, constructed at selected sites on a relatively flat topography for livestock watering. They receive their runoff mostly from open rangeland; thus, contour bunds are constructed to divert runoff into the dam.

Rock Catchments: Rock catchments are suitable in areas with massive unjointed rock outcrops. They are ground catchments with high runoff coefficients as the impervious catchment provided by the rock yields plenty of water from a limited amount of rainfall. They provide relatively cleaner water; they allow gravity flow supplies; and where there are suitable sites for rock catchment dams, they are one of the cheapest and effective means of storing rainwater.

Water Trucking

In some situations, the trucking of water may be the only viable approach to ensuring water supply for pastoral livestock during drought and emergencies. The approach is relatively expensive and has limited sustainability.

Any plan for water trucking should be fully costed and matchend against the overall benefit expected for livestock owners including the timeframe and eventual exit strategy. Some key issues for consideration are:

Management Issues

Staff management and supervision - successful trucking operations require consistent and sustained staff inputs. This includes a need for competent, experienced management and supervision. However, it is also important to ensure that drivers and assistants are kept motivated through proper reimbursement and careful attention to other needs including subsistence allowances and personal security considerations.

Monitoring deliveries - with capable and reliable supervisory staff working in collaboration with community leaders it is possible to ensure the correct number and amount of deliveries. Without careful monitoring it is quick and easy for fraudulent operators to offload supplies along the route and to claim payment for non-delivery unless beneficiaries are made aware of what they are supposed to receive.

Contracts - clearly worded contracts should be written and signed between agencies and trucking contractors, specifying delivery targets and mutually acceptable methods for measuring deliveries. Checks should also be made to ensure that no detrimental effects are felt by existing populations due to the withdrawal of trucking facilities from their usual work.

Design Issues

Selection of water sources - use of the selected source/s should be approved by all relevant authorities and user groups. Seek local advice regarding the ownership and rights to any proposed water source. Potential water sources often include urban supplies belonging to private companies, schools, churches etc. Should water be extracted from surface water sources such as rivers and lakes then additional arrangements will be necessary for the loading of trucks.

Trucking routes - should be surveyed and properly assessed to avoid problems with degradation over time and periods of inclement weather. Before entering into trucking agreements, routes should be identified and surveyed

including all bridges, fords and other obstacles. The type and suitability of road surfaces should be assessed noting any possible difficulties due to future inclement weather or gradual degradation of surfaces. The cost of, and methods for dealing with these problems and mitigating against future disruption should be considered as early as possible.

Selection and maintenance of fleet and equipment - use only appropriate means of transport, taking into account loading and bearing capacities of trucks and various road surfaces. Major issues to consider are

Cost and availability of fuel - ideally, it should be possible for drivers to refuel without making major detours away from the trucking route. This may require fuel to be brought in separately, adding to the logistical complications of the operation.

Spare parts - should be readily obtainable.

Maintenance - may affect the decision regarding the type of transport that will be used by the trucking operation e.g. trucks or tractors and trailers with bowsers or bladder tanks.

Distribution Issues. In addition to the water distribution issues, the effective distribution of water from tankers will require:

- Easy access and turn-around space for vehicles
- Good drainage
- Adequate storage
- Easy offloading into communal facilities (i.e. not into individual containers)

It is important to note that initial deliveries should be extremely well managed and well thought out to ensure the safety of agency staff and beneficiaries alike. There may be a great deal of anxiety present among the beneficiaries whose livestock may already be highly stressed and dehydrating fast. These people/animals will be impatient to receive water. It is important to let people know that additional, regular supplies will be arriving after initial deliveries have been made. If possible, try to build up ad-equate stocks of water quickly.

Relocation of livestock is often implemented as part of the response to an emergency (either as part of the indigenous response or coordinated by external agencies). Where this is occurring, trucking of water may be required to support the migration. This situation will add considerably to the already complex logistics of water trucking.

Challenges in Water Service Delivery in Pastoral Areas

- Inadequate infrastructure, which is often unfairly distributed due to inadequate financing.
- Environmental degradation due to inappropriate placement of permanent water sources, which causes degradation of the fragile rangeland environment and leads to loss of grazing areas, conflicts and increased vulnerability of pastoral communities to drought.
- Inappropriate technology choices, which the community cannot sustainably manage and which encourage environmental degradation.
- Poor design and construction of the water structures, due to limited numbers of skilled persons in pastoral areas.
- Poor capacity of beneficiary communities in management, operation and maintenance, due to poor skills, unwillingness to pay for water, poor accountability/financial mismanagement, gender imbalances in the management of water systems, cultural barriers, political interference etc.
- Development actors (including governments) undermining sustainability attempts through haphazard donations to communities that hamper plans towards self-reliance. This is often due to an incoherent and uncoordinated approach to water development, which is seen by many water actors as the overall impediment to development of sustainable water supply systems in the pastoral areas.
- Limited capacity of lead agencies, like line government departments, to provide the required technical support to community water supply systems

Daily Water Requirements for Livestock

To estimate the approximate needs of the livestock population in an area, the following figures (Table 2.63) for daily water requirements may serve as a rough guide:

TABLE 2.63. APPROXIMATE WATER NEEDS FOR LIVESTOCK

Type of Livestock	Average water requirement (litres)	Frequency of drinking
Camels	60–80	Every 4 or 5 days or longer
Cattle	30–40	Every 1 to 3 days
Equines (donkeys, mules, horses)	15–25	1 or 2 days
Sheep	4–5	1 or 2 days
Goats	4–5	Preferably once a day
Pigs	0.5–2.5	Preferably once a day
Poultry	0.05–0.15	At least once a day

Livestock Health and Market Infrastructure in the Rangelands

For livestock production to be sustainable in the drylands, other supporting infrastructure should be present. At the moment Kenya's infrastructure especially in the drylands (roads, holding grounds, stock routes for livestock, etc.) is in poor state, and hence unconducive to efficient livestock marketing. These include livestock health and market infrastructure.

- **Feeds storage facilities**: these are farm structures used to conserve harvested feed materials for future use. The size of the hay barn depends on the amount of feed materials expected to be stored. These should be located in areas which are easily accessible and should be well ventilated. In wet seasons in the ASALs, primary production normally increases hence the availability of excess feed materials. The conservation of these materials is necessary to alleviate feed scarcity during emergencies. Large scale storage facilities have been initiated by County Governments and NGOs to help in communal feed bulking. Their development together with governance structures for their operation can help minimize the impacts of disasters to livestock keepers.

A communal feed storage facility

- **Holding grounds:** These are demarcated areas where livestock are temporarily held before being transported to the market, slaughter or elsewhere. Some of these have been non-existent in pastoral and agro pastoral areas due to factors such as insecurity, lack of water, feed and fences. These need to be enhanced to increase the competitiveness of the livestock sector in these areas.
- **Slaughterhouses:** The capacity for utilization varies considerably in the ASALs. Their management is mainly in the hands of civil servants who are technical staff rather than administrative staff, with sometimes little knowledge. It would be preferable for these units to be managed by professional staff that have good experience in financial and commercial management, and even better if they are managed by the private sector. More financing is required to equip, modernise them and improve quality of livestock and livestock

products.

- **Cattle races and crushes**: This is being used for operations such as branding, spraying and giving injections. More specialised work such as ear marking, dehorning, castration, foot trimming, weighing, artificial insemination, pregnancy testing and veterinary operations requires a crush to firmly restrain an animal.
- **Dips and spray races:** These are used for controlling external parasites in livestock. Spray races are mostly good for smaller numbers of livestock but plunge dips can handle thousands of animals. Most of the communal dips collapsed in the ASALs due to different factors including breakdowns, mismanagement and land use factors. There is a need to revive them in order to control tick-borne diseases and outbreaks as well as to minimize pollution brought about by individual spraying.
- **Loading ramps and collecting yards**: Loading ramps are necessary to load stock into lorries for transport to market or transfer to other grazing areas.
- **Roads and stock routes**: Livestock routes are critical infrastructure for facilitating movement of livestock from one region to another. In most cases, most are blocked and are poorly serviced and protected, this has negative impacts on livestock, people and the environment. There is a need to map, service and improve them to ensure livestock reach the market in good health condition.
- **Transport infrastructure**: In Kenya, the transport of livestock and livestock products is directly related to other freight traffic, and cattle transport is usually subsidiary to the main freight. Most livestock trucks in developing countries are not specially adapted for cattle transport and although specialised livestock trucks could transport more livestock, they are more expensive and may not find a return load. Trucks are held mainly in the private sector making transport of livestock and products expensive. Formation of associations of transporters and some credit for truckers can be recommended.
- **Livestock market, Sale and auction yards:** These form the backbone to livestock marketing in the arid and semi-arid areas. These are mostly located in trading Centres where stakeholders including brokers, livestock keepers, traders among others meet to participate in livestock marketing.
- **Firebreaks:** These are tracks of about 4 metres wide (and can be of any length) which are cleared of all vegetation**.** They are usually constructed in large scale ranches and are essential because they help prevent the spread of dry season fire wild grass fires which destroy grazing pastures and cause tremendous reduction in livestock production
- **Livestock improvement centres (LICs):** These play an important role in improving local herds through training and availing of improved breeding stock either through improved stock either through bulls
- **Social infrastructure:** These include hospitals, health centres and schools
- **Livestock development centres (LDCs):** This is an institution provided with staff offices and houses, training venues and animal health laboratories. The main objective is to bring veterinary services closer to pastoralists, provide a base for mobile extension teams and also act as venues for training staff and stock owners.
- **Quarantine stations:** These are intended to quarantine animals and prevent them from contracting communicable diseases. They also provide spaces to treat animals that might have been exposed to diseases and certify that animals in these zones are disease free. They are needed to facilitate access of livestock and livestock products into the high-value markets which has been lost to other producers in the world due to the failure of the country to implement effective disease control measures as required by the prospective importing countries.

The national livestock policy emphasises on the Government to develop and rehabilitate livestock marketing infrastructure in collaboration with the relevant stakeholders. In particular, the local county councils to plough back some of the cess revenue towards the development of livestock marketing infrastructure in order to improve local livestock market. It will also protect the existing holding grounds and other infrastructure from acquisition by private developers or any other entity.

Challenges in rangelands infrastructure – Water service delivery as an example

- Inadequate infrastructure, which is often unfairly distributed due to inadequate financing.
- Environmental degradation due to inappropriate placement of permanent water sources, which causes

degradation of the fragile rangeland environment and leads to loss of grazing areas, conflicts and increased vulnerability of pastoral communities to drought.

- Inappropriate technology choices, which the community cannot sustainably manage and which encourage environmental degradation.
- Poor design and construction of the water structures, due to limited numbers of skilled persons in pastoral areas.
- Poor capacity of beneficiary communities in management, operation and maintenance, due to poor skills, unwillingness to pay for water, poor accountability/financial mismanagement, gender imbalances in the management of water systems, cultural barriers, political interference etc.
- Development actors (including governments) undermining sustainability attempts through haphazard donations to communities that hamper plans towards self-reliance. This is often due to an incoherent and uncoordinated approach to water development, which is seen by many water actors as the overall impediment to development of sustainable water supply systems in the pastoral areas.
- Limited capacity of lead agencies, like line government departments, to provide the required technical support to community water supply systems

Policies and strategies for rangelands infrastructure

1. **Sessional Paper No. 1 of 1999, on National Water Policy on Water Resources Management and Development** sets out a framework intended to bring about a culture that promotes comprehensive water resource management and development with the private sector, with community participation as the prime movers in the process to guarantee sustainability. The government's role would be largely to provide policy guidelines, an enabling environment and to regulate the sector

2. **The Water Act, 2002** provides for the management, conservation, use and control of water resources, and for the acquisition and regulation of rights to use water; as well as providing for the regulation and management of water supplies and sewerage services.

3. **The Draft National Policy for the Sustainable Development of Arid and Semi-Arid Lands of Kenya focuses on the revitalization of the Arid and Semi-Arid Lands (ASALs)** - One of the priority areas for development in this policy document is water resource management and development to improve livestock productivity. Water availability, its appropriate development, and its use, are key to the development of the ASALs. The development of surface water through appropriate community-owned water harvesting structures, such as pans and dams, will be emphasized, while groundwater will be developed based on social and environmental sustainability criteria

4. **The National Water Resources Management Strategy (NWRMS) (2007-2009**) -The strategy provides a guide for assessing, maintaining, enhancing, developing and managing the limited available, renewable, freshwater resources, using an integrated approach and promoting its use on a sustainable basis

5. **EMCA) 1999, (Wetlands, River Banks, Lake Shores and Sea Shore Management) Regulation, 2009 (Cap. 387) –**These Regulations, made under the Environmental Management and Co-ordination Act, 1999, make provision for the management, conservation and sustainable use of wetlands and wetland resources and the sustainable utilization and conservation of (resources on) river banks, lake shores, and the seashore. The Regulations, among other things, set out general conservation and management principles, define duties of the Standards and Enforcement Review Committee and District Environment Committees.

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SECTION THREE

ALETRNATIVE LIVELIHOODS

This section covers six modules namely: Beekeeping/apiculture; Irrigated agriculture for horticultural high value crops; aquaculture/fish farming, Doum palm; Acacia gum and Arabic resins and finally, rabbit TIMPs.

3.1.MODULE 1

BEEKEEPING (APICULTURE)

Beekeeping or apiculture is the art and science of keeping and managing the honeybee for the economic benefit of humans. The Honeybee (*Apis mellifera)* is a social bee that lives in large colonies of up to 100,000 bees. Beekeeping has been identified as a viable agricultural enterprise that could alleviate poverty and sustain rural employment in the ASALs. Beekeeping is widely considered as one of the poverty-alleviation strategies both by the Kenyan Government and other players supporting rural development in Kenya. Unlike other agricultural practices, beekeeping can be undertaken with minimal infrastructure, little capital and easy-to-learn skills hence providing an excellent opportunity for diversifying agricultural production. It is estimated that Kenya produces between 15,000 and 25,000 MT of honey as well as 1000 and 5,000 MT of beeswax annually. This is a relatively low amount considering the estimated potential of 100,000 and 10,000 MT, honey and beeswax respectively. Beekeepers are dependent on the use of low productive traditional hives which results in poor quality honey. Traditionally bees were kept in baskets, pots, guards, barks and logs. Modern beekeeping was introduced in the 1970's to improve hive productivity. The introduced modern hives included: Kenya Top Bar Hive (KTBH), Langstroth hive and other modified Top bar hives. Beekeeping has many benefits which include; -Source of food, source of Incomes from hive products, i.e., Sale of honey, beeswax, royal jelly, pollen and propolis, employment, pollination services-the honeybee is a good pollinator, medicine-hive products are good Apitherapy products, and conservation of biodiversity among others. Despite its potential benefits, beekeeping faces a lot of challenges including environmental degradation (forest cultivation, fires, charcoal burning etc.), low adoption of improved technologies, Bee-phobia, and increased use of agricultural chemicals among others.

List of sub-Modules

- Sub-Module 1: Siting Apiary and establishment
- Sub-Module 2: Beekeeping equipment and accessories
- Sub-Module 3: Colony and pest/predator management
- Sub-module 4: Bee behaviour
- Sub-Module 5: Bee forage /Bee plants
- Sub-Module 6: Hive products
- Sub-Module 7: Honey harvesting and processing
- Sub-Module 8: Beekeeping Cost Benefit Analysis
- Sub-Module 9: Value addition, Packaging and Market presentation.

3.1.1 SUB-MODULE 1: SITING APIARY AND ESTABLISHMENT

Introduction

An apiary is a bee yard where honeybees are kept for their products and pollination services. It's a bee boma where numerous honeybee colonies are reared for their economic benefits. The number of colonies to be kept in the apiary depends on the availability of bee forage and presence or absence of other colonies in the vicinity

Factors to consider in apiary sitting

- Availability of Bee plants (forage)
- Availability of bee colonies
- Source of water
- Shelter
- Proper drainage
- Accessibility of the site
- Proximity to public amenities, minimum 200-300 metres
- Low incidences of pests, predators and diseases
- Minimum exposure to pesticides
- Distance to the next apiary(ies) radius of 2-3 kms.

Apiary establishment

There are various steps to be followed when establishing an apiary:

- Site preparation which involves clearing the site of any excess vegetative growth, removal of unwanted materials such as big stones, logs and tree stumps
- Site fencing. Surrounding the apiary with a barbed wire fence excludes livestock, predators and human beings from accessing the apiary
- Establishment of a live hedge fence which makes the bees fly high when leaving and returning to the apiary thus reducing the risk of them becoming a nuisance in the neighbourhood. Fast growing bee plants e.g., Kei apple, Lantana camara are recommended as a live hedge fence
- The hive hanging posts should be well treated to prevent termite attack and not rot easily. They should be sunk about two feet below the ground surface and about two metres apart for suspending KTBH.

Hive placing and hanging

Hives can be placed on a bench/flatform at least 1m above the ground. This is gender friendly unlike the traditional beekeeping where hives were hanged high on trees hence a preserve for men.

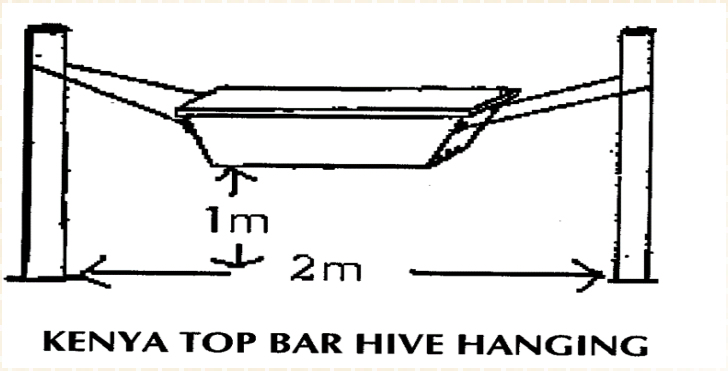
Langstroth hives placed on a bench

Langstroth hives placed hanging

Langstroth hives placement

Hives are hanged so as to offer a convenient working height and also to prevent pests and predator attack. This working height is preferably 1m above the ground. There are several hanging patterns including-Single pattern, line pattern, T-pattern, cross pattern, zig zag pattern, goal post and suspension.

Line pattern cross pattern



Routine management of apiary

For successful beekeeping, it is very important for a beekeeper to devote some time in managing his/her apiary. The following managerial practices are recommended:

- The Apiary should be well fenced with barbed wire or a live hedge to keep off animals and people. The hedge should be more than 2 metres high so that bees can fly high when leaving or returning to the apiary. This height reduces exposure and risk of being stung
- The apiary should be kept clean by cutting overgrown and undesirable vegetation around the hives so as to prevent pests from accessing the hives
- Hives should be properly hung and hanging wires must be greased frequently to keep off crawling pests
- Plant more bee plants in and around the apiary to ensure that the bees are provided with enough forage
- Dilapidated post should be repaired or replaced
- Provision of a Bee house to; enhances security of the hives, provide shade especially in hot areas and control pests and predators.

The Beehouse can be constructed by use of locally available materials such as: Grass thatching for roofing. Rafters and mud for walls. Any available timber for hive stands. Holes are drilled on the wall. Hives are placed on stands with their entrances corresponding with holes (about 1m from ground level) on the walls. Pipes of about 2 inches wide and 6 inches long connect the hive to the outside through the wall and works as bee entrances.

3.1.2 SUB-MODULE 2: BEEKEEPING EQUIPMENT AND ACCESSORIES

Introduction

This sub-module addresses issues of beehive technologies and up scaling to reach the larger community for increased productivity, promote technologies and innovations and enhance livelihoods of the beekeeping community.

Traditionally bees were kept in baskets, pots, guards, barks and logs.

Basket hives

Log hive

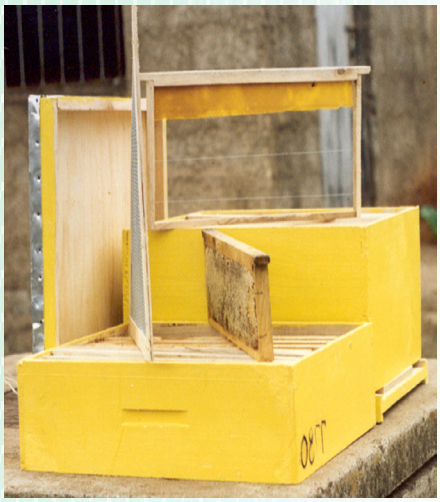
Advantages of traditional Log-hives

- Occupation rate is higher because of hanging high up on trees
- Yields more wax and propolis
- Affordable and durable
- Easily available depending on type of hive.

Disadvantages of traditional Log-hives

- Management is limited
- Not easy to control pests, diseases predators
- Harvesting, methods can lead to loss of bees and quality of products
- Not gender friendly
- Causes uncontrolled logging of indigenous trees.

Modern beekeeping uses modern hives mainly KTBH, Langstroth and various modifications of the Top bar hive.




Langstroth hive KTBH

Advantages of KTBH

- Bars may be taken out for inspection
- Effective for wax production
- Good for comb honey production
- Because the queen excluder isolates the brood from the honey, the queen is not disturbed during hive inspection and harvesting
- Honeycombs can be taken out without upsetting the nest's young.

Advantages of the Langstroth hive

- The combs are not destroyed during harvesting hence bees can take shorter time to refill
- Its expandable by adding a super box so that bees can continue adding combs-important for deferred harvesting
- Relatively higher yields per hive.

The Langstroth hives require farmers to have a honey extractor to extract honey from the frames. It is not suitable for beeswax production since the combs are not produced.

General advantages of modern hives

- Easy to manage
- Eases inspection
- Helps in pest control
- Honey harvesting/quality-makes it possible to harvest only ripe honey
- It is gender sensitive-easily workable by women and youth
- It produces on average higher yields of honey.

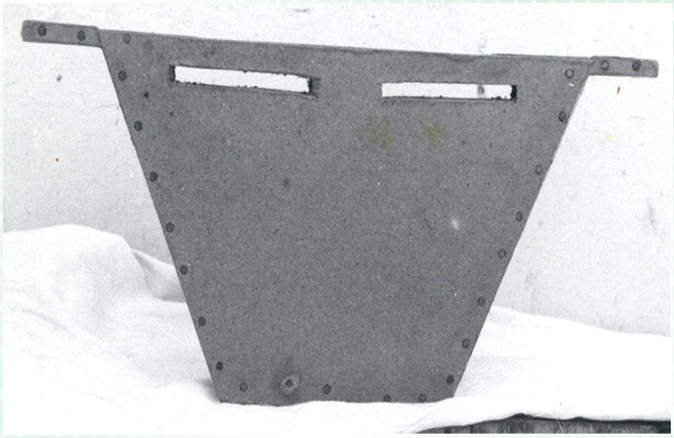
Disadvantages of modern hives

- High cost of hives compared to log hives
- Hives not readily available in many areas
- Low occupation rates
- Requires higher management skills.

Beekeeping accessories include:

Langstroth Catcher box Catcher box

Smoker Hive tool



Feeder box protective kit -courtesy of NBI

Bee brush

3.13 SUB-MODULE 3: COLONY AND PEST/PREDATOR MANAGEMENT

Introduction

Honeybee Management is the art and skill of keeping bees for maximum production of bee products and services (pollination). Production of bee products is attained through natural instincts of the honeybee colony and adaptation of management techniques to specific situations. Therefore, beekeepers should observe, understand and exploit behavioural aspects of the bee colonies. To understand and manage honeybees, one must be familiar with the development and activities of the colony and seasonal changes that take place. Colony management is the rearing of bees for maximum production of bee products and services. The Key aspects of colony management include;

Inspection

Hive inspection should be done at least once a month in order to get acquainted with your bees. This will enable you

to know:

- When the colony needs a new queen
- The colonies with cool temperament
- Productive colonies
- Colonies with less tendency of swarming
- Performance of the queen.
- Presence of pest, predators and diseases
- Whether the honeybee colonies need supplementary feeding
- When to make a division
- When to harvest the honey.

The findings of the inspection inform the decision to make e.g. a week colony requires feeding, whether to do colony division, harvest etc. The beekeeper is required to be in a bee suit, have a lit smoker, hive tool and bee brush.

Inspection procedure

- Approach the hive from back (away from hive entrance)
- Smoke the hive through the entrance
- Lift the lid and smoke onto the bars/frames
- Remove the top bar/frame and inspect
- Once inspection is completed replace the lid or cover.

During inspection, the beekeeper is advised to have an assistant.

Hive inspection-courtesy of NBI

Stocking of hives

This can be done through:

- Natural occupation/let alone method-the hives are left alone in the open and bee swarms naturally occupy the hive
- Trapping of swarms
- Bait the hives or the catcher boxes
- Set hives/catcher boxes strategically during swarming season
- Check for occupation periodically
- Occupation may take days or weeks
- Block the catcher box entrances before moving the trapped swarms to the desired site
- Division of colony.

Dividing a strong colony to produce two can also be done for the purpose of:

- Controlling natural swarming
- Increasing number of bee colonies.

Seasonal management

The honey bees in tropical climates needs a managerial programme during these four periods.

Dearth Period. This is a time of the year when nectar and pollen are not available to the bees. Egg laying activities may therefore decrease or stop due to the fact that there is no food to feed the brood. Dearth period may be caused by:

- Prolonged dry season which will not permit flowering.
- Very heavy rains, which prevent bees from foraging.
- The combination of prolonged dry season followed by very heavy rains.
- Very cold weather which prevents bees from going out to forage; instead they cluster to produce heat. In hot areas, put the hive under shade so that bees have time to search for their food source instead of wasting time trying to cool the hive. Shelter hives to keep them dry where rains are heavy and provide proper ventilation. Enhance pest control measures since the colonies are most vulnerable at this time. Provide water if there is scarcity and feed the colony if necessary.

Build-Up Period. This is a time when bee plants start flowering and bees start to bring in pollen and nectar. At first the bees will bring only enough to start egg laying by the queen. During this period all the stores are used for comb building, egg laying and brood rearing. At this time, there should not be less than two top bars full of honey so that the queen may lay eggs to maximum capacity and brood rearing may not drop. Feed any colony that runs short of food. The more stores of honey, the greater the number of foraging bees that would be available to collect the crop thus the bigger the harvest. At the onset of the build-up period, the following should be done:

- Remove all combs which are wrongly built.
- Check that the brood are in compact blocks on the combs. This indicates a good queen.
- Merge queen less and small colonies to medium sized ones.
- Help the bees to expand their brood nest by putting an empty top bar in between the brood bar and the top bar containing honey and pollen.
- Look for hiding places for small hive beetles and wax moth larvae, which the bees cannot remove.
- Merge queen less and small colonies to medium sized ones.
- Help the bees to expand their brood nest by putting an empty top bar in between the brood bar and the top bar containing honey and pollen.

Honey-Flow Period. Bee plants are in full bloom during this period. Bees bring in nectar and pollen in greater quantities for their daily requirement and therefore utilise the period for storing. There will be a daily increase in stores if the colony was properly prepared in the build-up period. Otherwise, the colony will use the honey flow period to build-up instead of collecting excess nectar and pollen. At this time the queen should be restricted to the brood area (by using a queen excluder) to leave the other combs to be used for storage. In case of a Langstroth hive, give extra supers when the colony is ¾ full. They will serve both for the distribution of the colony population, which will control swarming, and to store excess food. In the case of a Kenya Top Bar Hive, harvesting can be done to create space. This period is the peak of all preparations because maximum storage of honey is the beekeeper's goal of the craft.

Harvest Period. The honey harvesting period starts about ten days after blooming. By then the honey is ripe and ready for harvesting. There is always a danger of bees consuming the stores if harvesting is delayed.

Colony Feeding

The natural food of the honeybee consists of nectar, honey, pollen and water. It is normally not necessary to feed bees when pollen and nectar are abundant. Feeding should be avoided because it can result in storage of sucrose instead of nectar. However, under certain conditions, feeding is necessary to sustain the bee colony. These conditions are as follows.

New Colonies

A new colony that has entered a hive by itself, been transferred from a catcher box or made by division or package bees will develop much faster if it is fed. About two litres of sugar syrup should be given for 2-3 weeks.

Drought

Conditions Under severe drought conditions, colonies may be fed to prevent them from absconding or migrating. The amount to be fed requires considerable experience and knowledge of both the bees and local conditions so that the sugar is not wasted.

Stimulative Feeding

If it is known that a honey-flow will begin at a certain period, the bees may be fed, up to two months before flowering to stimulate brood rearing so that the adult bees reared will be ready to forage in the field when the flowering period starts. When stimulative feeding is done bees will store more surplus honey because they do not have to build up their numbers for the honey-flow. Feed two litres each week, however, this amount can be increased with time to keep pace with the increased number of bees.

Sugar Syrup Feeding Equipment

The Feeder Box -The feeder box is exactly the same length as the top bar of a Kenya top bar hive. It is shaped as the hive, both sides covered with hard board. There is a slot on either side of its upper part where bees enter to get to the syrup. The opening on the top frame is used to pour the sugar syrup and to prevent bees from drowning, pieces straw or small sticks are used as floaters. One empty top bar is removed and replaced with the feeder. The feeder can be left in the hive for several days. Always inspect the colony being fed, do not leave stale or fermented syrup in the hive as this will affect the bees, and they could even abscond. When all the feeding is done remove the feeder box and replace the top bar or frame.

Cans or Pails -Cans or pails of sugar syrup are placed on top bars or the frames within the brood chamber. A super without frames is then placed on top of the brood chamber and the hive cover placed over it. The cans or pails containing sugar syrup can also be placed on top of the hive; however, this will encourage robbing.

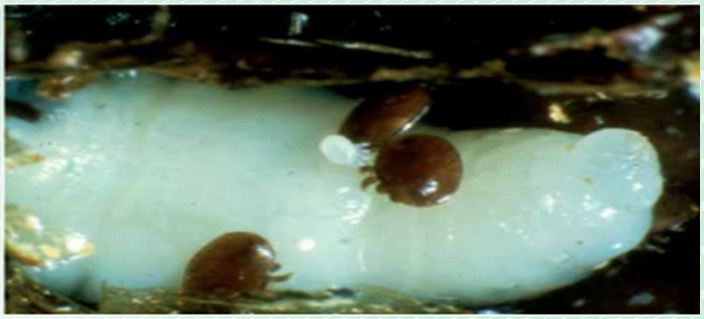
A plastic bag feeder -The plastic bag encloses much of one or two frames in the out edge of the brood nest, bees feed from the upper opening just like they do from a feeder box. Bees can also be fed by pouring the sugar syrup directory to the cells of empty combs in the blood chamber

Bee Pests and Predators

There are quite a number of honey bee pests and predators that directly affect the honeybee colonies and thus affecting the production of both the hive products. There are no identified honey bee diseases in Kenya but a number of them are experienced in other parts of the world. These pests could be insects, reptiles, amphibians, birds and mammals.

Insects -The most troublesome of these pests includes beetles, safari ants, sugar ants, termites, varroa mites/bee louse and pirate wasps

Varroa mites



Feeds on haemolymph of all the life stages of honey bees

Mites are found on the body of the adult bees, in the brood cells or on the debris from the hives

- Control -On adult use icing sugar technique.
- Check mites in sealed cells and check on the body of the bee.
- Control -Alcohol wash.
- -use sticky bottom board.

The sticky board traps the mice/louse when they drop on to it.

- Reptiles-lizards and snakes. Feed on bees eventually leading to absconding.
- Control a) Maintenance of clean apiaries b) Constant hive inspections to chase away such pests.
- Amphibians- Frogs and toads. Sit on hive entrance and feed on bees directly.
- Control a) Avoid hanging hives in swampy areas. b) Constant hive inspections to remove such pests.
- Birds - e.g., European Bee Eater (Merops apiaster)- Feed on bees as they fly out of hives

Control-Chase or scare the birds away from the apiaries.

Honey Guide Indicator. Feed on bees as they fly out of hives. Lives symbiotically with the honey badger. It's a minor pest.

- Mammals-man and Honey badger (Mellifera capensis) are the greatest pests for bees.
- The honey badger- Feed on honey and brood b) Destruction of hives.

- Control -a) Suspending hives by use of hanging wires. b) Fencing the apiaries with thorns, chicken wire meshes c) Use of a strongly built bee house. d) Railing of trees or hanging posts with a slippery metallic material e.g. tin.

3.1.4 SUB-MODULE 4: BEE BEHAVIOUR

Introduction

Honeybee behaviour is a phenomenon portrayed by honeybees in the course of their daily activities in a colony. Some are genetically influenced while others are dependent on external stimuli. It is very important for a beekeeper to understand and utilise behaviour patterns presented by bees for better management.

The following are bee behaviours important in management of the honey bee:

Defence

Stinging should be considered as a defensive behaviour instead of a form of aggression. Bees normally react in a definite pattern of behaviour to specific stimuli associated with an intruder. Guard bees stay at the entrance watching for any enemy that dares provoke the colony. Once one attacks many others follow. They do this to protect the brood and honey by stinging. Once the sting is deposited, alarm pheromone is suddenly liberated from the stinging apparatus. It lingers at the stinging site after the bee has departed, thus exciting further stinging responses. Colony defence behaviour is one of the most significant kinds of activity not only because bees are able to protect themselves very effectively but also because stinging behaviour is one of the greatest deterrents to keeping bees. Beekeeping can be pleasurable through understanding of stinging behaviour and can reduce

Scouting

This refers to a situation where scout bees leave the hive in search of new food sources or nesting sites. Worker bees scout for food outside the hive in all directions. The ones that find good forage go back to the hive and relay this information to the rest of the colony through a series of dances which recruit foragers to gather food for the colony until the source is exhausted. Bees scout for new nests in preparation for swarming.

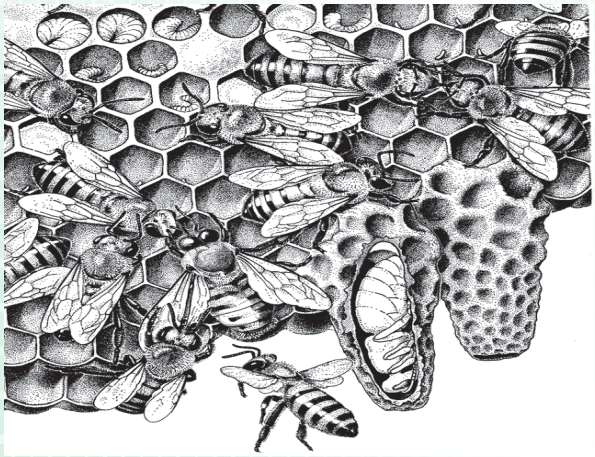
Swarming

This is a natural way by which honeybee colonies multiply or reproduce thus increasing their numbers. An increase in bee population causes overcrowding in the hive and thus the worker bees feel the need for rearing additional queens in preparation to divide and depart. Honey Bees usually swarm after flowering seasons. Swarming is uneconomical to a beekeeper since part of the colony is lost. A swarm consists of a queen, a large number of worker bees and a few drones.

A swarm of bees

Causes of swarming:

- Overcrowding as a result of increase in the number of bees leading to high temperature, high humidity, high carbon dioxide concentration and poor ventilation in the hive.
- Hereditary. Certain bee strains particularly in the tropics have an inherent tendency to swarm
- Effects of the season – During the honey flow period, most of the comb cells are filled with honey thus reducing space in the hive.
- Signs of Swarming - Building of swarm cells along the edges of the combs, Clustering of bees at the entrance of the hive, Presence of many drone cells and drones, Increased aggression – bees become more defensive and sting a lot, rocking movement of the bees, Bees produce a hissing sound.



Swarm cells along the edge of comb

Control measures

- Making Divisions – this reduces the population of the bee colony thus creating more space in the hive.
- Destroying swarm cells so as to stop the emerging of new queens.
- Switching positions of weak colonies with stronger ones so that the weaker colonies can receive the field bees from the stronger colonies.
- De-queening and re-queening. This involves the introduction of a queen with a less swarming tendency.
- Clipping the wings of the queen as a temporary measure.

Once the honeybee swarm leaves the hive, they cluster either on a tree branch or a post and only stay for a few minutes or hours. During this period worker bees scout for a better place, if there is an empty hive or catcher box, they would occupy it; if not, they take off to an unknown destination. Such swarms can be trapped by farmers when spotted using a catcher box or a net since such bees are usually not aggressive.

Supersedure

This is a natural behaviour of replacing a queen with a new one in a bee colony.

Causes of supersedure.

- Failing queen due to old age, injury, sickness
- Death of the old queen
- Accidental loss of queen. Signs of Supersedure
- Presence of queen cells on the surface of a comb
- Egg laying pattern of queen is irregular
- Weak colony
- The activities of the bee colony are reduced
- Workers start to lay eggs.

This kind of behaviour (i.e., natural replacement of a queen) is acceptable and the beekeeper is advised not to destroy the supersedure cells since making a queen in such conditions is acceptable.

Signs of supersedure

- irregular egg laying pattern of the queen.
- Weak colony.
- Reduced hive activities.
- Supersedure cells on the surface of combs.

Supersedure cells on surface of cob

Absconding

This is a sudden departure of the whole colony of bees from a hive. It is caused by

- Due to pests, predators, diseases.
- Shortage of food and water.
- Unfavourable weather conditions – floods, high temperature.
- Poor management aspects e.g., over-harvesting, mishandling.
- Effect of fire and chemicals.

There are no obvious prior signs but on opening the hive the beekeeper is likely to see an intact brood nest and food stores.

Control Measures

This can be achieved by adoption of proper management practices that address the causative issues. The beekeeper must create conducive environmental conditions and protect the bee colonies from physical and chemical disturbances.

Migration

This is a seasonal movement of the whole colony from one region to another due to adverse weather conditions. Migrating bees normally follow specific routes. Migration is caused by:

- Scarcity of bee forage (nectar and pollen) and water.
- Genetic factors.
- Seasonal weather variations.

Control Measures

- Improvement of environmental conditions e.g., planting trees, provision of water.
- Practicing migratory beekeeping.
- Feeding bees during adverse conditions.
- Selection of bees with less migratory tendency.

3.1.4 SUB-MODULE 5: BEE FORAGE /BEE PLANTS

Introduction

Honey bees depend on a number of plants for nectar, pollen and propolis. They make honey from nectar while pollen is fed to brood as a source of protein. Propolis is used to seal any unwanted openings in the hive.

Importance of Bee Plants

Knowledge of bee plants is important because it helps the beekeeper in the following ways:

- Provides information on the food resource of bees
- To determine geographical distribution of the honey sources
- To know plants that are toxic to bees and man.
- To know the blooming period so as to time honey flow seasons.
- To identify bee attractant plants species like Oscimum
- Gives knowledge on plants that have adverse effects on bee products e.g. Aloe, Euphorbia, and Sisal.
- Understand some plants which are repellents to bees e.g. Mexican marigold (Targetes minuta) puff ball (Walburgia longimanii) etc.
- Understand some of the plants with attractive flowers, yet bees do not benefit due their morphology or lack of nectar. e.g. Nandi Flame, Bougainvillea and *Lantana camara*.

Major Bee Plants

These provide nectar and pollen for bees. They range from cultivated crops, exotic and indigenous plants. The following are some of the examples of such plants.

Callistemon citrinus -bottle brush *Acacia senegal* (Nectar and pollen)

(Nectar and pollen)-exotic indeginous

Sunflower (nectar and pollen)-cultivated Cucumber-Nectar

Pollination services

As bees gather pollen and nectar from plants, they cause pollination of plants. Pollination, therefore, is the transfer of pollen grains from the anther to the stigma of a flower. There are two types of pollination: (i) Self-pollination: Within the same plant (flower) or within two flowers of the same plant. (ii) Cross-pollination: pollination between two close flowers of the same species borne by two different plants.

Factors affecting pollination

- The colour of the flowers brightness creates attractiveness to the bee (insect). Petals (corolla) portray the brightness. Other parts of the flower can become coloured while the flower (corolla) is not attractive.
- Nectar: All flowers with fused corolla secrete nectar, which attracts insects (bees) hence promote pollination.
- Scent: Some flowers emit a sweet scent which attracts bees from a distance. Emissions from other plants are offensive and irritating to humans, but are immensely liked by pollinators.
- Inflorescence: Individual flowers of some plants e.g. Acacia and Sunflower are inconspicuous so they are massed together into a dense inflorescence, which evidently become much more showy and attractive. Dense inflorescence has the very advantage of closeness so every chance of being pollinated exists. Other plant species are also pollinated by zoophily i.e. birds, squirrels, bats and snails. Birds and squirrels pollinate plants like Erythrina abysisinica, Bombax (Ceiba pentandra), Rose apple and cape chestnut, Calondedrum capense. Others include syzygium cuminii and Bignonia spp.

Importance of Pollination

Pollination will not happen in some plants e.g. Cucumber, and castor oil without the aid of the honey bees and therefore fruit may be deformed due to lack of fertilization. Many crops produce more and better-quality fruit when cross pollinated than when self pollinated. Farmers can reap more benefits by keeping bees in big plantations by hiring out bees for pollination in addition to the honey crop. Advantages of Honey Bees as Pollinators:

- Honeybees visit more flowers than other insect pollinators because the pollen and nectar collected is for their own sustenance, brood rearing and food storage; whereas other insects collect pollen and nectar for their own use on the spot.
- Honeybee's population at any one time is bigger in comparison to other insects; with the exception of butterflies and locusts which may have bigger but very destructive populations.
- Honeybees are more manageable. Beekeepers may practice migratory beekeeping; that is honeybee colonies can easily be placed anywhere when they are needed.
- Fidelity to species. Normally honeybees work on a particular species of flower in a restricted area thoroughly rather than moving about from one kind of flower to another.
- Honeybees can communicate accurately the smell, distance and direction of food sources.

- Honeybees have special body adaptations e.g. cubicula and plumose hairs by means of which they can carry pollen. They also have honey sacs for carrying nectar.
- Honeybees are efficient pollinators because the bees collecting pollen must contact anther and stigma and they work faster than nectar gatherers. Therefore, we can conclude that honeybees are better pollinators.

3.1.6 SUB-MODULE 6: HIVE PRODUCTS

Introduction

Hive products are all products derived from the hive as a result of honeybee activities. The following are the main hive products: - 1) Honey 2) Propolis 3) Pollen 4) Bee venom 5) Beeswax 6) Royal jelly

Honey

Perhaps the most widely used hive product. Honey is presented in the market in different forms namely:

Unprocessed honey: this is honey that has just been harvested awaiting to be processed.

Semi-refined honey: this is honey where big comb particles have been manually removed.

Chunk honey: this has a piece of comb honey immersed in refined honey. This form is not common in the market.

Creamed honey: this is honey that has been allowed to crystallise under specific conditions. The crystals are fine and not visible and therefore it can be spread like butter on bread.

Physical properties of honey

Colour-ranges from light amber, amber, and dark amber, dark to light yellow or white depending on the source of nectar. Colour is measured by means of the permanent glass colour standards or the PFund Colour Grader.

Hygroscopicity: Honey is remarkably hygroscopic (the ability of a substance to absorb moisture from the air).

Viscosity: The ability of a substance to resist flow. Honey is highly viscous.

Thixotropy: Honey is relatively thixotropic; it has a tendency to form a gel due to large amounts of certain proteins e.g. Heather honey.

Thermal Conductivity: Honey is a bad conductor of heat.

Density: 1.39 to 1.4 gm per cm^3 at 20 ºC.

Aroma and flavour: Honey has a sweet aroma and taste.

Chemical Composition

Honey consists mainly of sugars, with the simple sugars (fructose and glucose) being dominant. The complex sugars (sucrose, maltose, lactose) occur in small quantities. Other components include water, vitamins, minerals, proteins, acids and enzymes.

Honey Crystallisation/Granulation It is normal for honey to crystallize or granulate naturally upon storage. Crystallization of honey is affected by the following factors - temperature, presence of foreign matter and the equilibrium between glucose and fructose sugars present in honey. In an ideal situation, the invert sugars in honey plays a major role in that the equilibrium shifts from glucose to fructose, which is more stable. For this reason, crystallized honey has more of glucose than fructose. For good quality honey, crystallization usually begins at the bottom of the container going upwards until the whole mass turns into one continuous solid. The type of crystallization in honey should as much as possible be uniform irrespective of the size of the crystals formed.

Uses of honey

Honey as Food: A major part of honey produced is eaten as Table Honey. Of the estimated annual world consumption of honey, 90% is eaten directly either as liquid honey, comb honey or chunk honey. It is also used as a sweetener in beverages, bread and cakes. The use of honey in baking improves moisture retention and thus increases storage life

and provides a richer flavour. Honey in confectionery is also used in preparation of sweets. However, sweetening agents like sugars or syrups tend to replace honey because they are cheap. Honey has also been used to make honey mead which is a popular alcoholic beverage in many African communities.

In Medicine: Honey is a component of many commercially manufactured pharmaceutical products such as cough syrups. It is also used as a palatable sweetening agent in general pharmaceuticals.

In Cosmetics: Honey is valued in cosmetics due to its moisturising effect on the skin thus, it is incorporated in the manufacture of various cosmetic products like soaps, creams, shampoos and conditioners.

Honey as a Preservative: The use of honey as a preservative is very common with the older generation. Traditionally honey was used as a meat preservative. The high sugar concentration combined with antibacterial nature of honey makes it an effective preservative

Propolis

Propolis is a sticky, gummy, resinous substance gathered by honeybees from the buds and bark of plants and trees. The bees use it for sealing, strengthening, lining and preserving material inside the hive and around it.

Physical Properties: Colour: The colour ranges from yellowish green, reddish to dark brown. Taste: It is bitter in taste.

Chemical Composition: Composition varies from sample to sample depending on the source. Propolis comprises 50-55% resin, 10-15% volatile/essential oils, 30% beeswax and 5% pollen. Propolis also contains minerals, amino acids and bioflavonoids (biochemicals responsible for the healing process). Bioflavonoid is said to stimulate the white blood cells or lymphocytes, to produce interferon whose role is enhancing the body's resistance to virus infections.

Propolis utilisation

- Propolis can be used as a safe non-toxic food supplement.
- It can also be used to make grafting wax used by gardeners and crop growers to seal the union of plant tissue.
- Main uses of propolis are on natural food supplements and herbal medicine.
- Ancient Egyptians used propolis for mummifying their dead kings and queens.
- Propolis is also used in veterinary practice in ointment for treating cuts, abscesses and wounds of animals.
- It is also used for treating burns, external ulcers and eczema in humans.

Pollen

Pollen is the male germ plasma of plants. It is the main source of proteins, fats and minerals in the honeybee diet.

Physical Properties: The colour ranges from yellow, red to orange. It appears as fine grains/granules.

Chemical Composition: Pollen comprises of 20-25% protein, 27% carbohydrates mostly simple sugars (fructose and glucose), vitamins, free amino acids, lipids, enzymes and co-enzymes, pigments: xanthophylls and carotene, water and minerals (potassium, calcium, iron etc).

Pollen Utilisation

- Human beings use pollen as a food supplement because it is believed to boost the immune system.
- Build strength.
- Stamina and vitality.
- It is also used in creams to rejuvenate and soothe skin
- Pollen is used to rear insects and feed birds
- It can also be used as feedback to colonies during pollen- deficient nectar flows or to queen cell builders.

Bee Venom

Bee venom (apitoxin) is the poison ejected from the poison sac of the bee sting when a bee stings. It is synthesised by the venom glands of worker and queen bees.

Physical Properties. It is a clear liquid with a sharp bitter taste and aromatic odour.

Chemical Composition. Bee venom contains about 40% dry substance and hardens fast when in contact with the air. It contains water, peptides (mellitin – 50%, hyper and MCD (Mast cell degranulating peptides) apamine, histamine, dopamine and minimine.

Phospholipases A splits lecithin - a phospholipids which is widely spread in the body, turning it into lysolecithin which degenerates cell membranes. Hyaluronidase splits the hyaluronic acid – a constituent element of the fundamental substance of the conjunctive tissue, thereby favouring the spread of the active factors of the bee venom throughout the body. Its specific gravity is 1.313 and pH = 4.5. Bee venom is destroyed by digesting and oxidising enzymes, and is readily soluble in water and acids but is insoluble in alcohol.

Beeswax

Beeswax is obtained from wax cappings or empty combs. It is a very valuable product with beekeepers earning up to 5% of their income from wax production. Currently prices of beeswax are on a downward trend due to competition from petroleum-based waxes. At present the cosmetic industry is the biggest user of this hive product followed by the beekeeping industry for the manufacture of comb foundation sheets.

Preparation of Beeswax for Market Before beeswax is placed on the shelf for the purpose of selling, it must be prepared well having the following in mind. Beeswax should be free from organic matters such as bees, brood, debris, sand or any other undesirable materials. It should not be adulterated by blending it with other types of waxes such as paraffin wax, synthetic wax or any types of oil or fat (animal or vegetable). NB: The colour of beeswax varies from whitish yellow to yellowish brown. This will depend on the type of combs one uses when making the beeswax.

caption

Royal jelly

Royal jelly is a honey bee secretion that is used in the nutrition of larvae and adult queens. It is secreted from the glands in the hypopharyns of nurse bees, and fed to all larvae in the colony, regardless of sex or caste.

Developing queen larvae surrounded by royal jelly

Royal Jelly Utilisation

The main use is in the cosmetics industry as a moisturising agent in health and beauty products such as body creams. Added to a variety of other cosmetic products royal jelly's antibacterial, cleansing and textural properties account for its cosmetic popularity. Royal jelly is nutritious and is used as a health food and is often added as a supplement to other ingredients and vitamins which are taken as either capsules or as part of a beverage in confectioneries or mixed

with honey as a spread. It also boasts the immune system, strengthens nails, improves skin and hair. Royal jelly is also used by beekeepers to prime queen cells before grafting.

3.1.7 SUB-MODULE 7: HONEY HARVESTING AND PROCESSING

Honey Harvesting

The principal idea in harvesting honey is identifying the comb with ripe honey, free it of bees and take it away for processing. This entails shaking the bees off the combs, young bees normally cling on the comb therefore they are brushed off using a bee brush.

For Langstroth hive one can also use the bee escape (clearer board). Fix the bee escape between the brood box and the super. After 24-48hrs all the bees will be cleared off the honey supers. The supers can then be removed for honey extraction. Ensure the clearer board is removed and the supers replaced with empty ones.

Harvesting Procedure

- Follow the same procedures as in hive inspection and once the combs with honey have been identified harvest immediately by removing combs with ripe honey (a comb that is fully or three quarter capped) Capped honey from movable frames (Langstroth hive) is uncapped and placed into a honey extractor in order to extract the honey, after extraction the comb is returned into the super box so that bees can continue storing honey.
- Cut off the comb using a sharp knife or hive tool into a clean and dry bucket or other suitable container that has a tight fitting lid. The bees that cling on the surface of the comb honey must be brushed off using a bee brush before cutting it off. It is advisable to carry an extra honey harvesting container.
- Replace the lid of the container immediately so as to keep off bees. This is because during harvesting there is always a danger of robbing of honey by bees all over the apiary. In the case of harvesting from Langstroth hive, keep the honey supers well covered once they are removed from the hive.
- Combs with brood and pollen should not be removed during harvesting.
- Replace the top bars back into the hives and also leave some honey for the bees. It is also good practice to extract the honey from the combs with immediate effect since freshly harvested honey drips out of the cells more easily than the one that has been stored.

Honey harvesting from Langstroth hive

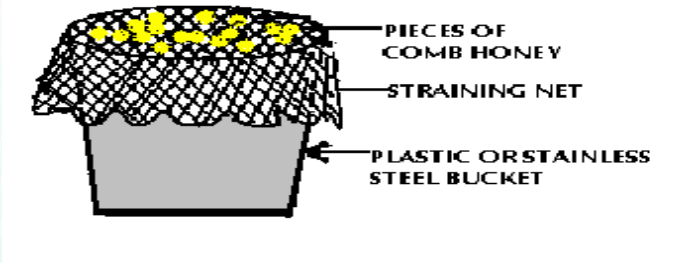
- Open top hive cover/lid and remove the honey loaded super.
- Put an empty super on top of brood chamber with queen excluder.
- Place the clearer boar on top of the empty super ensuring that the opening is facing upwards. Best time for putting clearer board is early morning then harvesting the next day early morning.
- Then superimpose the loaded super on top of empty super with clearer board. Replace the hive cover/ lid.
- Open top hive cover/lid and remove the honey loaded super.
- Put an empty super on top of brood chamber with queen excluder.
- Place the clearer boar on top of the empty super ensuring that the opening is facing upwards. Best time for putting clearer board is early morning then harvesting the next day early morning.
- Then superimpose the loaded super on top of empty super with clearer board. Replace the hive cover/ lid.
- (i.e. the next day) remove the honey loaded super (which now has very few bees) and the clearer board then replace the top cover/lid.
- After honey extraction the frames are returned into the hive (super) so that bees can continue storing honey. Harvesting can be done in three weeks to a months' time if nectar producing flowers are still in bloom.

Ripe honey-capped 2/3rd of the comb uncapping honey comb for processing

Honey Processing

Honey processing involves the removal of wax and any other foreign materials from honey.

Simple Straining Method: This method is suitable for freshly harvested honey. It involves the uncapping (removal of the thin wax layer that seals the honey cells) of the honey and allowing it to pass through a straining cloth or net into a clean and dry suitable container. The straining net (nylon mostly) is folded once, to form two layers and tied over the mouth of the container. The use of a wide mouth container to collect the strained honey is very efficient and faster since the honey will have a larger surface area to filter through. The liquid honey is then allowed to settle overnight, scum is then removed from the surface of the honey using a spoon before the honey is packed.



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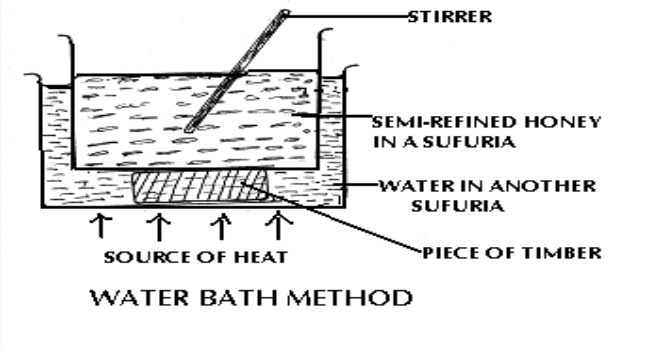
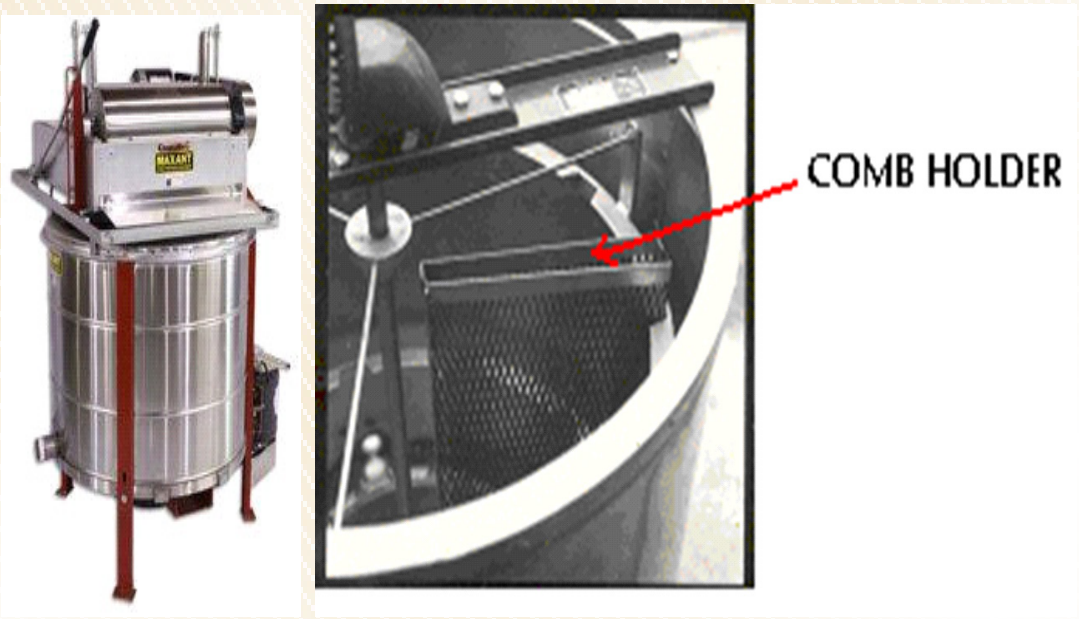
Water Bath Method: This is also referred to as batch processing. This method is suitable for semi-processed honey which has been stored for some time and possibly crystallised. Honey is first heated in a water-bath (indirect heating), up to 45^0 C– 50^0 C. Honey is heated to facilitate both straining and fast handling, secondly, to destroy yeast that may be present and may cause fermentation particularly if the moisture content is above 17%. The indirect heating method involves the use of two 'sufurias'; the smaller one containing honey is placed inside a bigger one containing some water and a piece of wood placed at the bottom so that the smaller one does not touch the bottom of the bigger sufuria. The honey that is being warmed must be stirred to distribute the heat evenly. A straining cloth is then folded twice (forms four layers) and firmly tied onto a clean, dry suitable container as in the case of simple straining method above. Once all the warm honey has passed through the cloth, cover the bucket with a lid, and allow it to settle for a minimum of 3 days to allow the scum to collect at the top of the strained honey.



Water bath method

Bulk Processing: It is used for large quantities of honey. In this method, honey is made to flow through a series of sieves of various sizes. These sieves are arranged in a concentric form, the finest mesh being on the outside and coarser on the inside. The semi-refined honey is heated to 45^0 C– 50^0 C in a sump tank and then flows by gravity through the sieves usually referred to as strainers; into a settling tank and is left there for at least 3 days. The scum collects on top of the strained honey, it is then removed and the honey packed.

Honey Extraction: This is a method used to extract honey from combs using a centrifugal force. The honey comb is uncapped using an uncapping fork or a warm knife. The frames are then placed vertically in an extractor which can either be manual or electric. Centrifugal force is then used to force honey out of the combs. The honey is then sieved into a storage container and allowed to settle overnight. Honey from top bar hives and traditional hives can also be extracted using this method by placing the combs in special comb holders.



Honey extractor

Pressing Method: Honey is forced out of the comb by pressing it out using a honey press. This should be done as soon as possible after harvesting. After pressing out the honey, it is then warmed using a water-bath and strained.

Honey Blending: Honey from different sources will have different characteristics. In order to bring uniformity, different honeys form the same geographical area could be blended. This involves mixing the honeys during processing so that the final product becomes homogenous and have the same physical and chemical properties.

3.1.8 SUB-MODEL 8: BEEKEEPING COST BENEFIT ANALYSIS

Introduction

Cost Benefit Analysis for a Beekeeping Enterprise

Is beekeeping an investment that pays? A Simple analysis can be worked out to find out whether beekeeping is an investment that pays. In this cost benefit analysis, it is important to take into consideration a number of assumptions in view of the fact that beekeeping is highly dependent on the vagaries of the physical environment.

Important Assumptions include:

- An economic unit comprises of at least 20 hives
- Occupation rate will be 80% through out the projects lifespan
- That the farmer is knowledgeable about beekeeping and will manage the colonies well
- Life span of the equipment will be 10 years
- Price changes for hive products will be insignificant over the 10 years

- The analysis is based on a fixed cost depreciation.

Variable costs to consider include Labour, transport and incidentals.

Consider income from Sale of Honey and beeswax from setting up a Beekeeping Enterprise Comprising of 20 Langstroth hives.

Assumptions include:

- Labour and incidentals will increase by 10% each year
- Transport costs will increase by 5% each year.

3.1.9 SUB-MODULE 9: VALUE ADDITION

Introduction

Honey is a major ingredient used in the preparation of various products that are of benefit to the human body. It is also used as a sweetener in various recipes.

Honey Formulae for External Use

Uses of honey

- Skin cleanser: Mix one egg white, 1 tsp. Honey and 1 tsp. Milk. Heat and apply mixture to clean skin leaving it on for at least half an hour. Wash off mixture when dry with hot water.
- Skin conditioner: Mix fresh milk, honey, ghee and dried avocado and bring to boil. Allow it to cool and apply 3 times a day.
- Surgical dressing: Clean the wound then apply pure honey directly or make a salve using 1 tbsp each of honey, olive oil and egg yolk. Spread the salve on surgical gauze and place on the burn. Repeat treatment when mixture dries out until the wound heals.
- Boil treatment: Warm or heat pure honey and apply on a boil to mature.
- Toothpaste: Use a mixture of 250 gms honey, 250 gms precipitated chalk, 250 gms orris root, 7 gms tincture of myrrh, 2 gms oil of rose, 2 gms oil of cloves and 2 gms oil of nutmeg.

Honey Formulas for Internal use

- Health drink: Use 2-3 tbsps of honey in water, herbal tea, yoghurt, milk or porridge before meals.
- Cough remedy: Blend ¼ cup honey, 1 tbsp lemon or lime juice and 1 tablespoon glycerine/menthol/eucalyptus oil. Take 1tbsp 3 times a day.
- Digestive disorders: Take 1tbsp of honey to relieve indigestion.
- Stress: Mix a cup of camomile tea to which a few fresh or dried mint leaves is added and a teaspoon full of honey. Allow the drink to steep for 3 minutes and drink while still hot.
- Replacing body fluids: 1 tsp of 'light' salt (half potassium), 1 tbsp of apple cider vinegar, and 1 litre of water and some honey.
- Inflammation of Larynx: add 1-2 tsps of honey to steaming hot tea and sip.

.HONEY RECIPES

Honey Cake

Ingredients:

- 1 cup butter/margarine.
- 1½ cups liquid honey.
- 4 eggs.
- 4 cups self-raising wheat flour.
- 2 teaspoons nutmeg.

Method:

- Cream margarine and honey together. Add well beaten eggs. Sieve flour twice and add nutmeg. Gradually add dry ingredients into the creamed mixture. Pour mixture into a large greased loaf pan. Bake 350°F for about ¾ to 1 hour.

Lemonade Concentrate

Ingredients:

- juicy lemons.
- 1cup honey.

Method:

- Wash, peel and remove seeds from the lemons.
- Blend the lemons at high speed until liquefied then blend in honey at low speed.
- The Beekeeping Technical Handbook 109
- Concentrate to 1 cup of water, to serve immediately or refrigerate for later use.

Honey Cookies

Ingredients:

- 1-cup butter/margarine.
- 1-cup honey.
- 4 egg yolks.
- 1 tablespoon grated lemon or orange rind.
- 4 cups of sifted self-raising wheat flour.
- 1 teaspoon lemon juice.

Method:

- Cream butter and gradually add honey. Beat in egg yolks. Add lemon rind, sifted flour, and lemon juice and
- stir well. Chill dough. Shape dough into small balls and arrange on greased cookie sheet. Brush with lightly
- beaten egg whites. Bake at 350°F for 10-15 minutes.

Honey Ginger Bread

Ingredients:

- ¼ cup oil (olive, sesame etc.)
- 1 cup liquid honey
- 2½ cups wheat flour
- 3 teaspoons ginger
- 1 teaspoon cinnamon
- ½ teaspoon salt
- 1 teaspoon bicarbonate of soda
- 1 teaspoon baking powder
- 1 cup plain yoghurt
- 1 egg

Method:

- Mix yoghurt and honey then add to well beaten egg.
- Sift flour, cinnamon, ginger, soda, salt and baking powder into a separate bowl.
- Add egg mixture, beat well and blend in oil.
- Pour mixture into a large greased loaf pan.
- Bake 350°F for about ½hr to ¾ hr.
- Allow to cool fro 5 minutes and remove from baking tin then serve.

Cough Mixture

Ingredients:

- 4 Tablespoonfuls of Honey
- 1 large Garlic bulb
- 1 large ginger
- 4 Lemons

Method:

- Squeeze out lemon juice into a cup
- Peel the garlic and crush into a paste.
- Peel and grate the ginger.
- Mix garlic, ginger and lemon juice then blend and sieve.
- Add 4 tbs of honey to the mixture.
- The mixture turns greenish brown depending on the honey colour.
- Allow it to rest for 10-15mins then use it within 5 days.

The Beekeeping Technical Handbook

- Dosage: Adults: 2 - 3 tbsp every 3 hours.
- Children 1-2tbsp every 3 hours.
- NB: The mixture is most effective on the onset of the cough/flu.

Further Reading

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3.2 MODULE 2
AQUACULTURE

Introduction

The term aquaculture broadly refers to the cultivation of aquatic organisms in controlled aquatic environments for any commercial, recreational or public purpose. It involves breeding, rearing and harvesting various forms of marine and freshwater life. Fisheries and aquaculture provide essential nutrition, support livelihoods and contribute to national development. Aquaculture-fish farming offers farmers a land use diversification without big demand on land. The aquaculture fish farming has an important role to play in: Gender equality since it can be practiced by women and youth; Poverty reduction as an income generating activity and Food security where the fish is a nutritious food item in the community. Particular kinds of aquaculture include fish farming, shrimp farming, oyster farming, mariculture, pisciculture, alga-culture (such as seaweed farming), and the cultivation of ornamental fish marine organisms under controlled aquatic environments e.g. water tanks, cages, tanks, pods etc. It can involve the farming of two or more different organisms of different trophic levels where the wastes of one organism can be food for the other organisms and thus safeguarding the environment from wastes.

There are four major aquaculture facilities (i) freshwater pond culture; (ii) rice-fish culture or integrated fish farming; (iii) brackishwater finfish culture; (iv) mariculture involving extensive culture and producing fish/shellfish (e.g., oysters, mussels, cockles) which are sold in rural and urban markets at relatively low prices. In Kenya, aquaculture is mainly divided into mariculture, which is still at an infancy stage, and a more progressive freshwater aquaculture. Fish can be cultured in one of four culture systems namely; ponds, raceways, recirculating systems or cages. A cage or net pen is a system that confines the fish or shellfish in a mesh enclosure.

Aquaculture farm facilities and their surroundings should be maintained in a clean and hygienic condition. Containers, equipment and farm facilities should be maintained in good condition for ease in cleaning and sanitising. Successful aquaculture takes into consideration the biology of the aquatic species such as feeding. Water flow and temperature needs disease prevention and engineering design like water source and water quality study, pond and tank containment systems, water filtration and aeration. Kenya is endowed with an extensive network of aquatic ecosystems, which support commercial production of critical volume of fish that is required to fill the growing gap in national fish supply and demand, as captured fish catches decline.

This module is divided into eight sub-modules as listed below:

- Semi-Intensive Culture Systems and Management Practices.
- Intensive Culture Systems and Management Practices.
- Fish Breeding and Genetics.
- Fish Nutrition, Feed Formulation and Management Practices.
- Fish Health Management and Biosecurity.
- Fish Post-Harvest Technologies and Value Addition.
- Fish Marketing and Supply Chains.
- Aquaculture as a Business.

3.2.1 SUB-MODULE 1. SEMI-INTENSIVE CULTURE SYSTEMS AND MANAGEMENT PRACTICES

This sub-module discusses semi-intensive pond-based systems comprising of earthen, liner, concrete and wooden raised ponds (Figure 3.1). Semi-intensive aquaculture, particularly in the tropics, accounts for nearly 70% of the finfish production of the world. The bulk of this production is based on a handful of species, the most important being the cyprinid species, such as Chinese and Indian major carps, feeding low in the food chain. In the culture practices the endogenous food supply is known to play a major role, and equally the exogenous food supply is very diverse; the latter often ranging from simple mixes of ingredients to pelleted feeds of various forms. In Kenya, the bulk of aquaculture production is still by small-scale pond-based culture systems and practices.

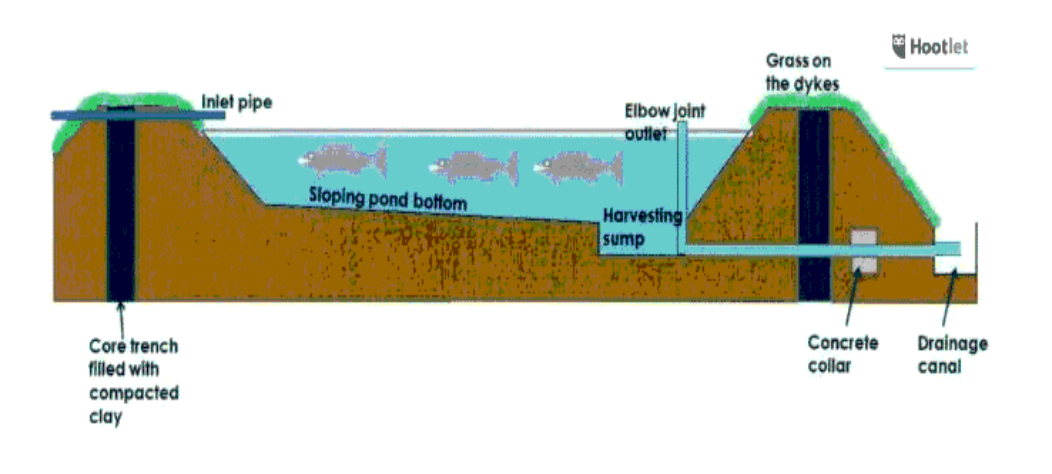


Figure 3.1. A cross-section of a complete pond showing the position of various structure

Semi-intensive culture systems depend largely on natural food produced in-situ. However, the production of natural food is enhanced by application of organic or inorganic manure or combination of both. At this level, the practices are known as low-cost semi-intensive system. Further intensification in these systems are attained by increasing the stocking density and application of commercially available or farm made feed or locally available agricultural byproducts like bran of rice, wheat, maize etc., and various types of vegetable de-oiled cakes as supplementary feed. In semi-intensive feed and manure based freshwater carp culture, feed alone amounts to 60-70% of the total production cost. As a result, feed based culture of low valued fish species have limited acceptance among the resource poor farming communities. Low cost semi-intensive systems are followed extensively in small undrainable family ponds and relatively larger community ponds, pens erected in lakes etc. These are closely integrated component of the family farming system being practised. The integration becomes more visible when livestock housings are brought closer to the aquaculture facilities or the livestock animals are housed over or near the pond. The water is not only used for aquaculture but also for irrigation of crops, husbandry of livestock and other domestic purposes. Again, the wastes and by-products from crop/horticulture and excreta from livestock farming activities are efficiently recycled in the aquatic ecosystem in the form of high valued protein rich food.

3.2.2 SUB-MODULE 2. INTENSIVE CULTURE SYSTEMS AND MANAGEMENT PRACTICES

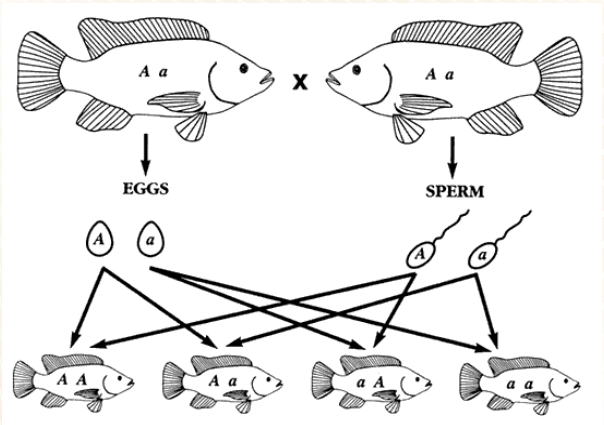
The trainees in this sub-module, will learn how to design, assemble and operate efficient, intensive culture systems such as recirculating aquaculture systems (RAS), raceway systems, cages and aquaponic systems. Intensive culture systems are high inputs - high output-based systems which require infrastructure facilities, large investment and adequate managerial skill. Such systems depend largely on complete and commercially available feed, oxygenation of the system, exchange or circulation of water etc. Intensive culture uses very high densities of culture organism (e.g., 200 000-300 000 shrimp PL/ha/crop) and is totally dependent on artificial, formulated feeds. Both systems use small pond compartments of up to one ha in size for ease of management. The sub-module emphasizes on the design of low-cost small-scale aquaponics systems and highlights their associated challenges and lastly the use of Information and Communication Technology (ICT) in managing and operating these systems. The sub-module will further focus on Best Management Practices (BMPs) and their importance in increasing aquaculture productivity and conservation of natural ecosystems. Finally, the module addresses the key roles of fish farmers and other stakeholders in implementing BMPs.

Tilapia Intensive aquaculture Technology re-circulation system (Photo: aquaculture-israel.com

3.2.3 SUB-MODULE 3. FISH BREEDING AND GENETICS

This sub-module highlights the protocols to be used in fish breeding of commercially important fish species in Kenya e.g., Nile tilapia, African catfish, African carps (*Barbus spp*, *Labeo victorianus)*, and ornamental fish. The faster growing tilapia strains demonstrate continued increase in growth rate in genetic improvement programs and superior profitability for farmers in Africa and South Asia, with reduced environmental impact. New traits characterized in tilapia promise better performance and adaptation to climate change through tolerance to low dissolved oxygen conditions, resistance to tilapia lake virus (TiLV), and improved feed efficiency. In Kenya, there is a high demand for quality certified fish seed for improved aquaculture productivity. To enhance the production of quality seed, there are several documented fish breeding and genetics techniques available which include chromosomal manipulation, hybridization or cross-breeding, hormonal sex reversal, GIFT YY male technology, gene transfer and selective breeding.

Fish genetic breeding is a process that remoulds heritable traits to obtain neotype and improved varieties. For the purpose of genetic improvement, researchers can select for desirable genetic traits, integrate a suite of traits from different donors, or alter the innate genetic traits of a species. Major progress has been made in aquaculture genomics for dozens of fish and shellfish species including the development of genetic linkage maps, physical maps, microarrays, single nucleotide polymorphism (SNP) arrays, transcriptome databases and various stages of genome reference sequences. Thus, new molecular genetic tools (SNP array, reference genomes, linkage maps, genetic markers for host disease resistance) will underpin genomic selection, accelerate development of resilient fish strains and promote sustainable management of aquatic genetic resources. Genomic information provides powerful tools to enhance physiological research, the results of which may be used for optimization of husbandry practices, feeding and feed formulations, breeding technologies, or non-genetic selection or screening (e.g., epigenetics, proteomics, and metabolomics).



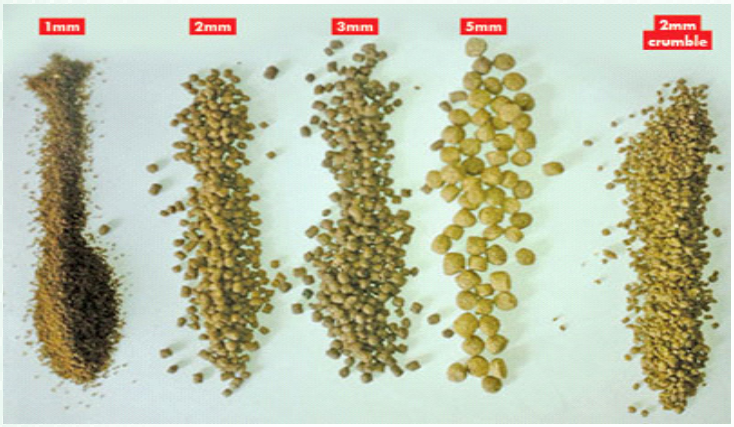
Fish inbreeding and brood stock management. Source: fao.org

3.2.4 SUB-MODULE 4. FISH NUTRITION, FEED FORMULATION AND MANAGEMENT PRACTICES

This sub-module specifies the training competencies needed to produce cost-effective cottage/supplementary and commercial pelleted fish feeds. It involves the following: sourcing of especially locally available fish feed ingredients, feeds formulations using the locally available feed ingredients, feed processing for the different fish species and growth stages, feeds conversion ratio, feeding strategies; the relationship between feeding and water quality in culture systems, and feed storage.

Proper nutrition for fish is dependent on the quality of the ingredients used to make their feed, how it is formulated (recipe), the techniques and equipment used in producing it, care taken during storage and the feeding technique applied. The following criteria need to be taken into account in selecting ingredients for fish feed: 1. Nutritional value (protein, fat, carbohydrates and fibre); 2. Availability (seasonal or annual); 3. Price and cost to transport; and 4. Any pre-treatment needed to make the ingredient more digestible. The ingredients must be kept in a dry place that is protected from sunlight and rodents, in order to maintain them fresh. Ideally, ingredients should be purchased within a week prior to producing the feed. All ingredients selected must be dry. Any ingredients purchased fresh – such as brewer's spent grain – must first be dried (pre-treated). Each ingredient is then ground to obtain a fine meal (≤ 800 µm is optimal) to facilitate mixing with other ingredients. Each ingredient must be ground separately to avoid any contamination or undesirable mixing. The milling machine must be cleaned carefully between ingredients. Once each ingredient has been ground, sifting is recommended (ensuring that the sieving mesh size is ≤800 µm) to eliminate any coarse particles and obtain a homogeneous powder. Once the ingredients are ready, a recipe is prepared based on the nutritional requirements of each species of fish targeted (tilapia, African catfish, common carp, etc.) and their respective stage of development (larvae, starter, grower and finisher). A specific recipe must be produced for each species of fish and each stage of development. Good recipe combines several ingredients to provide the necessary nutrients to provide balanced nutrition for proper growth and development of the fish.

Fish should be fed at least twice a day (at 9.00 and 15.00) or three times a day (at 9.00, 12.00 and 16.00). Fry or fingerlings, however, need to be fed at least five times a day (at 8.00, 10.00, 12.00, 14.00 and 16.00) as their stomachs are still very small. Feeding rates diminish as the fish grow. Fish may be fed 8 per cent of their weight per day at the starter stage, declining gradually to 3 percent at the grower stage and 2 per cent at the finisher stage. Pellet size, however, increases as the fish grow larger. It is recommended that fish be fed when the weather is fine and not when it is raining. During the feeding process, fish should be visually checked to see whether they are eating and active. If they are not eating, feeding should be stopped and the water quality verified.



Tilapia Feed Formulation and Feeding Technique. Source: Fish-feed-extrude.com

3.2.5 SUB-MODULE 5. FISH HEALTH MANAGEMENT AND BIOSECURITY

The sub-module on fish health management and biosecurity specifies the training competencies required for fish health and biosecurity. Fish health management is a term used in aquaculture to describe management practices which are designed to prevent fish disease. It includes the practices, procedures and policies used to prevent the introduction of disease-causing organisms. The occurrence of disease outbreaks in fish farming may be due to poor

husbandry practices since the disease- causing organisms are always in the environment. Diseases cause problems until the fish become stressed through inadequate dietary or environmental conditions. Since fish consumers would want to have an assurance that fish products are safe to eat, retailers have a responsibility of ensuring the quality and safety of fish for human consumption. The farm management needs to ensure that biosecurity principles are observed in all farm operations.

Once fish get sick it can be difficult to salvage them. Successful fish health management therefore begins with prevention of disease rather than treatment. Prevention of fish disease is accomplished through good water quality management, nutrition and sanitation. Without this foundation it is impossible to prevent outbreaks of opportunistic diseases. The fish is constantly bathed in potential pathogens, including bacteria, fungi, and parasites. Even use of sterilisation technology (i.e., ultraviolet sterilisers, ozonation) does not eliminate all potential pathogens from the environment. Sub-optimal water quality, poor nutrition or immune system suppression generally associated with stressful conditions allow these potential pathogens to cause disease. Medications used to treat these diseases provide a means of buying time for fish and enabling them to overcome opportunistic infections, but are no substitute for proper animal husbandry.

3.2.6 SUB-MODULE 6. FISH POST-HARVEST TECHNOLOGIES AND VALUE ADDITION

This sub-module will train on specific competencies required for fish post- harvest and value addition. These two aspects (post-harvest and value addition) comprise several processes, including transportation and handling fish hygienically; processing fish using different value enhancing techniques; preparation of fish using different recipes; maintenance of good quality fish products; packaging, branding and certifying fish and fish products and preparation and storage of fish safely for longer shelf life.

Post-harvest operations are comparatively less labor intensive than the food production operations. The introduction and uptake of improved technology can help enhance product quality and safety, reduce food loss and waste, achieve environmental benefits, operate costs and time savings, and improve working conditions. Women – who often dominate the fish post-harvest sector – are highly reliant on technology, particularly in relation to fish processing by drying, salting and smoking. Processing is particularly necessary when there are inefficiencies or lack of a cold chain. The processing extends shelf life (by up to several months) and makes fish transportable over long distances.

Value addition is about seizing opportunities offered by the market. It involves the process of adding value to products (starting from raw materials), or adding “extra” features to a product (improving quality, making products more convenient or desirable, creating new products, reducing costs, etc.) which often results in greater economic value for the producer. There are two possibilities of adding value: (1) value capturing through the improvement of current production, processing, trading processes to increase productivity, reduce wastage and reduce costs, and by entering new markets with existing products. (2) Value creation through product innovation (e.g., new processed products). This enables fishers, processors or traders to tap into new and higher-value markets. It may entail producing a fish product for a special or new market (diverting low-value fish from animal feed to the higher-value human consumption market); improving end-product quality through better hygiene, handling and processing practices; applying processing and preservation techniques and technologies such as dehydration and drying, smoking or freezing; development of innovative products such as fish powders or fish-based products; and changing how fish is packaged and labelled. Value addition can involve certification by food safety and standards bodies.

3.2.7 SUB-MODULE 7. FISH MARKETING AND SUPPLY CHAINS

This sub-module provides trainers with skills that will enable them to assist aquaculture farmers to engage with markets using participatory methods. It guides on how fish and fish products can effectively be marketed market; formulate costing and pricing charts; prepare marketing tools; project supply and demand curve in the market; advertise and promote fish and fish products; maximize profit margin from fish sales and market fish in groups or clusters. It will also guide the process of market identification and selection of attractive enterprise options, based on information gathered from the market chain and analysis of local supply and demand trends and market access options.

Currently, Africa is a net importer of fish and fish products that supplies the rising populations, many of which are becoming increasingly urbanized. Improved logistics and Aquaculture Studies, market distribution systems, coupled with expanding aquaculture production and technological innovations and globalization, have enabled increasing regional fish trade. In addition, improved control in the harvesting process in capture fisheries and throughout the production process in aquaculture has enabled producers to understand the needs of consumers to further innovate the market and supply chains.

In Kenya, Lake Victoria is the largest fishery, contributing to over 82.5% of the total annual national fish production. However, unsustainable anthropogenic activities have led to the reduction of the natural fish stocks and catches. Demand for fish continues to rise owing to the rapidly growing population, increase in real incomes and ongoing changes in dietary trends. Given these circumstances, aquaculture is the most suitable alternative, complimenting capture fisheries to gradually satisfy the growing consumer demand which is expected to increase substantially in the future.

For markets and value chains, there is need for investigation of better market linkages; the formation of fish farming, processing and marketing clusters; local and foreign investment capital (Figure 3.2).

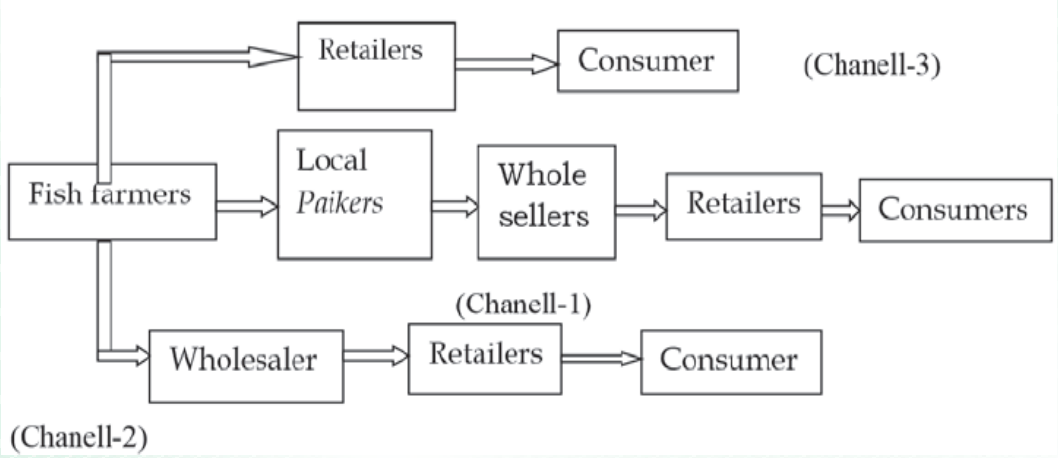


Figure 3.2. Fish Marketing and Supply Chains (Source: researchgate.net)

3.2.8 SUB-MODULE 8. AQUACULTURE AS A BUSINESS

There are several types of fishing farming businesses. You can grow fish to be eaten as, to be stocked for anglers, or to supply aquariums. Fish farming doesn't always require a large body of water. For many species, fish farms can be located indoors or outdoors. Getting started raising farmed fish does require a significant financial outlay. Good profits, depend on the type of fish farming done and the fish species. There are two basic requirements for successful aquaculture development:

- A market adapted to the local conditions and
- A suitable fish production system adapted to the local conditions.

In Kenya, the market potential for fish is high. This is mainly the result of Kenya's fast-growing population, but also because of the active promotion of fish consumption by the Kenyan government. In any economic activity regarding aquaculture as a business, new approaches focus on the understanding of aquaculture as a business. This understanding represents a significant shift in technical requirements. Whereas early aquaculture practices were focused on limiting factors that were biological and technical in nature (i.e., identifying species and disseminating the best technologies), it is now understood that the technology must be accompanied by effective capacity building in business and market planning. In this sub-module the following aspects need to be highlighted:

- Forms of business.
- Business management.
- Financial planning.
- Evaluation of the economic performance of aquaculture.
- Cash flow analysis.
- Budget analysis and financial statements.
- Preparation of a business plan.

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3.3 MODULE 3

. GUM (ARABIC AND RESINS) AND DOUM PALM

3.3.1 SUB-MODULE 1. GUM ARABIC AND GUM RESINS

Introduction

These are metabolic by-products of plant tissues either in normal course or as a result of disease injury to the bark or wood of certain plants. The uses of natural gums and resins in food, medicines and in varnishes or as protective coatings go back to very early times. The present-day uses of natural gums and resins are numerous and they are employed by a large number of manufacturing industries including food and pharmaceutical industries.

Gum Arabic Resources:

These are small thorny deciduous trees also known as Acacia senegal. It has dried exudation obtained from the stems and branches. They consist of Acacia Senegal varieties and/or Vachellia seyal red acacia which grow wildly in the Arid and semi-Arid Lands (ASAL) counties in Kenya.

Thorny branches and florescence of the gum acacia. Photo courtesy of KALRO

In its natural state, it comes in a variety of shapes, colours and sizes. The colour of the gum may vary from colourless through different shades of yellow, amber, orange, red and dark brown.

Uses of gum Arabic

- Used in food industry,
- pharmaceutical industry
- printing, ceramics and textile industries

Resins

Resins are plant scretions that exude or ooze out from the bark of the trees and tend to harden on exposure to air.

- Myrrh- the gum-resin exudate from the stems of Commiphora myrrha. It oozes and hardens to form lumps of varying shapes and sizes of variable colour from red, brown to dark brown.

Fully grown myrrh plant. (Source: https://www.indiamart.com)

Uses

- to make ink used in Quranic schools
- burning to repel snakes and offensive insects
- medicine for various ailments.
- Added in the manufacture of mainly essential oils, cosmetics, flavours, antiseptics and other medicines.

Commiphora holtiziana

- Hagar is oily resin exudate from the stems of Commiphora holtiziana. It oozes out and hardens to form lumps of various sizes and shapes with variable colour from yellow to dark brown or black.

Hagar plant (Source: https://www.indiamart.com)

Uses

- Hagar resin is used as acaricide against ticks, snake bites, scorpions, foot rot, mange and other livestock ailments.
- Herbal medicine
- essential oil in cosmetics.

Boswellia neglecta

Frankincense is the exudate from the stems of Boswellia neglecta. It oozes out in small droplets that harden to form nodules or large lumps. It is of two types, black and white.

Hagar plant (Source: https://www.indiamart.com)

Uses

- used as chewing gum.
- burnt as incense, perfume and medicine for a wide range of ailments.
- used as essential oil in perfumery, cosmetic as well as flavour industries.

Harvesting of gums and resins

Harvesting is done manually by labor-intensive traditional methods of tapping. Tapping is carried out shortly after the rains when the trees begin to shade the leaves. Tapping and collection of gum is carried out following a specific pattern around mid-September up to the end of the dry season, usually June. Tapping involves the shaving of a very thin, i.e., 2mm deep and 4-8mm wide, external layer of the bark starting at 0.5m from the base of the stem using a hand tool, „Mingaf" for resins and „Sonke" for Gum arabic. Once the 1st tapping is done, the 2nd tapping will take place after 30-40 days and involves a moderate widening of the wound, which was started during the 1st tapping. This tapping process will continue for three to four months until the wound has reached 4cm width. After each wounding/ incision, the exudates start to ooze and becomes dry in 2-3 weeks when it will be ready for collection. Collection of gums and resins from the wild is mainly done by women and herders during the dry months of the year.

Value addition for gums and resins

Post harvest handling of gum involves, storage, cleaning, sorting, grading, packaging and labeling. Most of the gums and resins produced in Kenya are exported in raw form except for a small quantity of the total volume produced that is processed for essential oils.

Challenges

The key challenges for the sub-sector are:

- Poorly developed markets and marketing systems resulting in low prices at the producer level
- Destruction of gum and resin producing trees for firewood, fencing and fodder
- Insecurity in some of the producing areas interfere with gum collection, storage and trade
- Low production of gum arabic due low adoption of best practices and land and tree tenure issues
- Low export volumes are partly due to lack of capacity to bulk enough quantities and lack of reliable suppliers
- Inadequate data on the resources, trade and marketing
- Lack of clear policies and strategies on development of gums and resins
- Inadequate incentives including access to credit by producers and traders
- Frequent and prolonged droughts affect gum production
- Un-regulated production system with collections from the wild resulting in unreliable supplies

3.3.2 SUB-MODULE 2. DOUM PALM PRODUCTS

The Doum palm fruit (Hyphaene thebaica) is a desert palm tree with edible oval fruit, originally native to the Nile valley. It is a member of the palm family, Arecaceae. The trunk of this small palm commonly branches into two like Y and often each branch divides again in a Y form, giving the tree a very distinctive appearance; it is dichotomous and arborescent in nature. It is listed as one of the useful plants of the world.

Doum palm tree and fruit

(Photo: HYPERLINK “http://www.istocchopen.com/”www.Istocchopen.com)

The Doum palm is one of the commonly available plants in several areas of northern Kenya and has potential to provide alternative livelihood options. The tree has economic, ecological, social and medicinal values for several communities. Some of the major products of Doum palm include baskets, sleeping mat, milk containers, brooms, ropes, hats and house thatch (makuti). The tree is also commonly used in traditional rituals and ceremonies among several pastoral communities. Doum palm further protects riverine ecology due to its confined growth suitability along the flood basins and tolerance to desiccation and livestock disturbance. Because of the various uses, there is growing interest in Doum palm in different parts of the world. This module covers the sub-module listed below.

Doum Palm Distribution

The Doum palm is a common palm in East Africa. It belongs to the Coryphoideae subfamily of the Arecaceae family of genus Hyphaenealso. It is predominant in Africa and has eight species, namely; H. compressa, H. guineensis, H. coriacea, H. macrosperma, H. reptans, H. petersiana, H. dichotoma, and H. thebaica. The palm tree is distributed in dry regions of Africa, Arabia, and India. In Kenya is widely distributed in hot areas (Figure 3.3). Common in dry northern areas along river courses and lakes (Turkana) also very common at the coast.

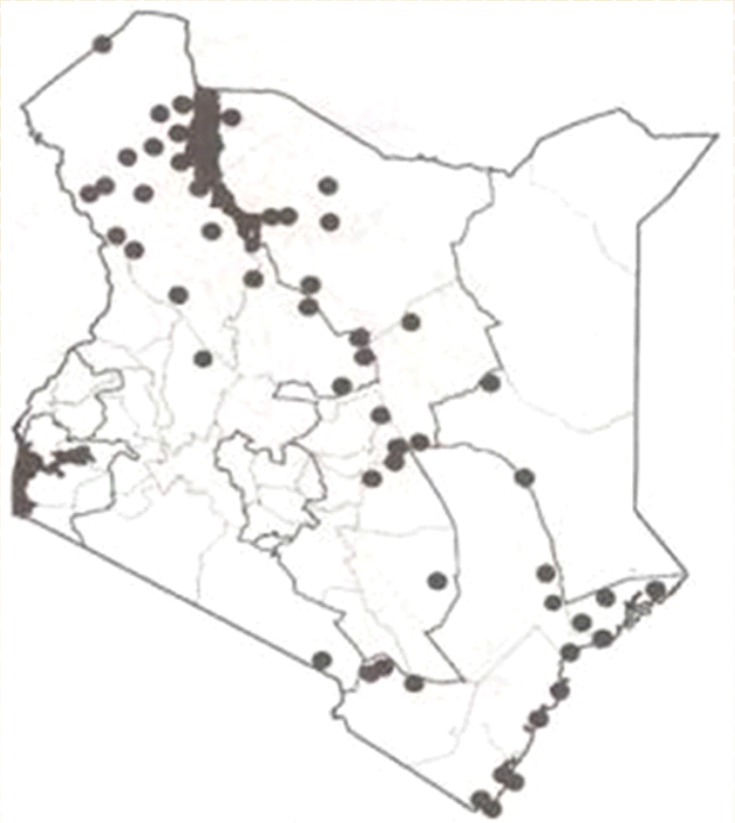

Figure 3.3. Distribution of Doum palm in Kenya (Photo: Maundu P. and Bo Tengnas)

The Doum palm is already adapted to ASAL and can sustain the ever-growing population in these areas yet there is very little focus on it. It grows in wadis and at oasis found in arid and semi-arid lands (ASAL) of Eastern African countries. This palm grows well between 0-1400m altitude, a mean annual temperature of above 28°C and a mean annual rainfall of 100-600mm. It is one of the few perennial plants vastly growing in ASAL. There are no known mechanisms for Doum palm propagation and conservation in Kenya.

Previous studies indicate that date, coconut, areca and African oil palm have been domesticated, but there is no documented evidence on Doum palm domestication, despite its importance in predynastic Egypt.

Doum Palm Conservation

Despite the important economic role and contributions, the Doum palm is still poorly understood and evaluated. Of concern is the steady decline of Doum palm populations in Africa due to destruction of their cradle habitat, drought, and overharvesting, thereby exacerbating pressure on the remaining African doum palm accessions leading to loss of

their gene pool. Intensive harvesting of juvenile leaves strongly affects the development of the Doum palm, Doulm palm wine tapping also presents a destructive practice that severely modifies the composition and density of the populations.

Harvesting, Value addition and Uses
Product making

To make various products from the Doum palm the following steps are usually followed.

- Step 1. Identify the best young suckers from the palm.
- Step 2. Cut the suckers - one per palm using a sharp panga or knife in a slanting shape.
- Step 3. Dry the lodop (young suckers) in the sun for about 3-5 days under a shade.
- Step 4. Make various types of doum products.

Products and uses

Various parts of the Doum palm produce different types of products. Some of the products include;

- The roots of Doum palm are used for treatment of bilharziasis while the fruit is often chewed to control hypertension.
- The hard seed inside the fruit, known as 'vegetable ivory', is used to treat sore eyes in livestock using charcoal from the seed kernel as well as making buttons and small carvings, and artificial pearls.
- Doum palm fruit is also a source of potent antioxidants.
- The fruit has a brown outer fibrous flesh which is normally chewed and spewed out.
- Doum palm kernel is edible when it is unripe but hard when it is ripe.
- The trunk is also used for local craft and construction.
- The foliage is used to make mats, ropes, baskets, and hats while the stem with the leaves is used for construction purpose.

In Turkey and Kenya, the powder made from the outer covering of the fruit is added to water and milk and left to stand to make a mild alcoholic drink; in other countries, the terminal meristem is tapped for making palm wine. The thin dried brown rind is used in the manufacture of sweetmeats, cakes, and molasses. The social and economic uses are shown below.

SOCIAL AND ECONOMIC USES OF DOUM PALM

Socio-cultural	**Economic**
Young fruits are used as special marriage beads worn during marriage and other ceremonies.	Doum palm protects the source. "We have water because of Doum palm"
Palm used as protection from misfortunes associated "bad eyes". It is usually tied around the neck of the new-born child and the mother. During marriage ceremony the bride, bridegroom and the best man wear palm around the knee.	It is an important grazing resource. It is salty and serves as a supplementary salt source to animals.
A special marriage hut called "Dulube" usually made by the mother for the newly married girl is made of Doum palm.	Eaten fruits are re-used as charcoal

Used as a symbol of blessing. “may God make you like Barrunya (Doum palm)

Threshed fruits mixed with blood are carried in skin containers and eaten like flour during food shortages.

Fruits are boiled and taken as tea in absence of sugar

Used in making brooms, mats, baskets, traditional containers and other products, which have economic value

Doum Hamper Baskets: (Photo: Rema Collections)

Marketing of Doum palm products

Marketing prospects should be located and developed promptly when one engages in Doum palm production. To make your Doum palm enterprise financially successful, you must have a way of selling the products. The marketing methods and the price may determine ability to pay expenses and make a profit. Some of the marketing channels include; relatives, neighbours, local stores or export. It’s important to ensure that one is acquitted with the county and state regulations governing the sale Doum plam products.

Further Reading

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3.4 MODULE 4

RABBIT PRODUCTION

Rabbit (*Oryctolagus cuniculus*) farming is one of the fastest growing micro-livestock enterprises in Kenya. They vary very much in colour and weight (1.4 to 7.3 kg). Some have small, erect ears while others have long hanging ears. The male is called a buck and the female is a doe and the young are referred to as kids.

The rabbit enterprise has the potential to be a cheap and sustainable means of producing high quality animal protein for the expanding human population in Kenya. Rabbits can be reared on cheap diets of forages and kitchen leftovers. They also utilise forages more efficiently than cattle, shoats and the rabbits pose minimal competition with humans for similar food. With good care a doe can produce up to 40 young ones per year compared with 0.8 for cows and 1.4 for ewes per year.

Housing for Rabbits

The housing of Rabbits is called rabbitry. Rabbits are sensitive to space and when not granted enough to freely move about, often exhibit abnormal behavior. This includes repetitive chewing of cage bars or over-grooming. The rabbitry should be an enclosed construction with proper ventilation, lighting, heating, and cooling systems. The construction can be cages, hutches or a house with enough room to accommodate their feeders, drinkers, kits and expansion of their population. Regardless, rabbits are good at taking care of themselves once you create a nice habitat for them. Better still, they permit you to keep your day job while you rear them if you so choose.

The rabbitry with proper ventilation and lighting systems

Breeding

The common rabbit breeds in Kenya are California White, Flemish Giant, New Zealand White and some other local cross breeds. Rabbits multiply rapidly and they start breeding at 4 to 5 months of age. The gestation period for the doe (female rabbit) is 31 days and she could give birth to between 6 and 10 kits (baby rabbits) in one go. Rabbits are also able to reproduce seven times a year. The doe being capable of producing up to 50 baby rabbits in a year translates into good income with successful breeding.For reproduction to take place, the buck and doe must be kept together to induce mating, after which they should be kept in separate cages. Bucks should be used for reproduction at least once in four days. The mating process could be scheduled for every three weeks or every six weeks depending on your level of patience. You should maintain the herd on a year-round schedule of 12 hours each of light and darkness to keep them breeding throughout the year.

Feeding Rabbits

Rabbits should be fed at least twice a day and provided with plenty of water. The best food for them is grass, they can also be fed cabbage and lettuce. Rabbits are naturally nocturnal creatures, preferring to eat at night. Rabbits should

have a daily diet of mostly hay, a smaller amount of fresh vegetables, and a limited number of pellets. Hay is the most important part of a rabbit's daily intake. Unlimited, high-quality grass hay, such as Timothy, orchard or brome, should make up the bulk of a rabbit's diet. Thus rabbits feed on a variety of feeds such as: green feeds that include growing plants such as grasses and leafy vegetables; root crops such as sweet potatoes, turnips and beets; cereals grains namely oats, wheat, barley, grain sorghums, corn and rye and milled feeds such as bran, middlings and shorts.

Rabbits feeding on vegetables

Disease Control

The most important factors for maintaining a healthy rabbit herd are cleanliness, good ventilation, close observation, and protection from sun and rain. Rabbits are susceptible to several diseases that can reduce production to unprofitable levels. The respiratory disease caused by Pasturellamultocida is responsible for decreased productivity and a high mortality rate in does.

To help prevent diseases, do not permit casual visitors entry into the rabbitry. They may introduce a disease or cause additional stress to the animals. Also, isolate any sick or injured rabbit immediately. Disinfect both the isolation cage and the rabbit's regular cage to avoid further spread of the disease.

For a good health program, you should keep accurate records of each animal. Provide each rabbit with a tattoo identification number or ear tag and attach an identification card with health and breeding information to its hutch.

Marketing and Sales

Not many people are involved in commercial rabbit production in Kenya. Because of this, it has been almost impossible for the few existing rabbit farmers to satisfy market demand. Therefore, once you set up your own rabbit farming business in Kenya, you are already on your way to becoming a silent millionaire.

You can make your sales in the local market. If you prefer not to stay all day long selling rabbits, consider getting somebody to sell them for you. Social Media is also a reliable platform for attracting patronage. Unfortunately, poor marketing is the main drawback for rabbit farming in the country.

Benefits of Rabbit Farming

There are several benefits of commercial rabbit farming in Kenya. The main benefits of rabbit farming business in Kenya are listed below.

- Source of cheap proteins(meat)
- Source of manure
- Income generation
- Source of employment
- Raw material for the leather industry(skin)
- Rabbits are very fast-growing animals like broiler chicken. They gain maturity fast and become suitable for slaughtering purpose within 4-5 months.

- Rabbit gestation period is less (generally between 28-31 days) and a doe give birth of kids after every 2 months. Each time one doe can give birth of 2-8 kids.
- Starting rabbit farming in Kenya requires very little capital or investment.

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SECTION FOUR

THE ENABLERS

Enablers are services and aspects that will facilitate implementation of interventions and realisation of the expected outputs. This section covers four modules The modules are: ICT; Cross-cutting issue; Agribusiness or farming as a business and Agricultural insurance .

4.1 MODULE 1
INFORMATION AND COMMUNICATION TECHNOLOGY FOR AGRICULTURAL ENTERPRISES

Information and Communications Technologies (ICT) refers to a diverse set of technological tools and resources used to create, transmit, store, and share or exchange information. The currently available ICT tools enable the collection of data, organization, processing and analysis of the data into information. The old adage that you cannot manage what you cannot measure is true, and hence measurements produce data. It is however important to understand that ICT tools are not deployed haphazardly without careful consideration of expected outcomes. All ICT systems are therefore driven by data which when well exploited provides evidence to guide informed decision-making and ultimately better outcomes. If an ICT system does not contribute to these outcomes, then it is better to avoid it altogether. In much the same way that railroads and canals dominated the nineteenth century, and roads and electricity dominated the twentieth century, ICT has become ubiquitous in the twenty-first century. Data has therefore become necessity in people's lives. The ICT tools are no longer independent but are embedded in everything because everyone is an ICT user in one way or another. This is also true in the rehabilitation and restoration of livelihoods and ecosystems that have been degraded or devastated by the calamities.

4.1.1 SUB-MODULE 1: ICT TOOLS FOR AGRICULTURAL PRODUCTION

Information and Communications Technology (ICT) initiatives seek to improve agricultural value chains and agribusinesses. Many ICT solutions entail improving access to reliable and timely information. Inequity in access to information allows those with information to take advantage of those without it (often farmers), even though much of the information is technically within the public domain. Because of the ever-lower costs and growing ubiquity of ICT, such as mobile phones and the networks needed to connect them, new avenues have been opened, offering critical information to farmers, small traders and business people. There are three types of ICT solutions, categorized in terms of the end result for the consumer: ICT for production systems management, ICT for market access services, and ICT for financial inclusion. All these platforms rely on data collection ICT tools such as smartphone-aided digital tools such as ODK and Kobocollect, mobile phones using short messaging service (SMS), personal data assistants (PDAs), radio-frequency identification (RFID) tags, geographic information system (GIS), and remote sensing. Electromagnetic and photographic data can also be recorded and transmitted remotely by satellites, aircraft or unmanned aerial vehicles (UAVs). All these innovations can be clustered into ICT tools: for agricultural production, market access services and financial Inclusion.

ICT Tools for Agricultural Production

The ICT tools that Information services to facilitate production systems management are the most prevalent category of ICT service for inclusive agricultural value chains. The information services involve four categories: (i) short-term productivity, such as weather information to help farmers decide when to plant or harvest; (ii) long term productivity, such as training on proper fertilizer usage; (iii) minimizing the negative effects of crisis events, such as information on how to protect crops from migratory pests or drought; and (iv) improving field-based risk management, such as information on the implementation of crop rotation to preserve the soil. The ICT tools for production systems therefore rely on information that is linked to helping farmers improve agricultural productivity, yields and profitability while minimizing risks. This covers ICT applications for production systems that involve short- and long-term productivity enhancement, minimize the negative effects of crisis events, and improve field-based risk management.

ICT Tools for Market Access Services

These include services that facilitate farmers' access to information on pricing of agricultural products such as inputs and outputs. In addition, they offer connections to and knowledge of suppliers, buyers and logistics service providers such as storage facilities and transport companies. These services also include ICT solutions that help the typically larger upstream and downstream firms, such as processors or exporters, to manage their operations and the quality of the produce better.

ICT tools for Financial Inclusion

This entails ICT solutions that allow formal and semi formal financial institutions and direct value chain players (e.g., using trade credit) to provide financial services in a more convenient, secure, flexible and low-cost manner.

Criteria for Selecting ICT tools for Agricultural Production Value Chains

The ICT tools are widely used to collect data, with the choice of technology depending on the kind of data needed. Another criterion concerns the need for an overall enabling framework for the utilisation of ICT technology in a given country. This macro condition puts in place regulatory framework that enables the establishment of ICT infrastructure. The more effective this framework is the less the effort required to tailor strategies that lead to increased application of ICT in agricultural production value chains. This is because a proper regulatory framework increases the chances of having basic expertise and infrastructure to build on. The following criteria should be considered when planning to use ICT for enhancing agricultural production value chains:

End User Needs

There are many potential uses of technology for improving the agricultural value chains, but not all can be applied. Multifaceted technology can complicate adoption and utilisation process, confuse various players and become cost-prohibitive. The ICT implementing party should therefore first listen to the end users and prioritize the challenges to be addressed. The target ICT users must be empowered to express their requirements and take a leading role in technology development, adoption and utilisation. Without end-user involvement, well-intentioned outsiders will make mistakes, perhaps even fail the process.

Functional Stability

There are many areas for improvement in the traditional agricultural value chains. It is therefore often more appropriate to use ICT solutions that have already been proven in other more advanced industries or use cases. There is seldom any need for agricultural value chain to use the most state-of-the-art technology, which often can have many bugs and other problems to be resolved.

Existing Infrastructural Support

Building communications structures from the ground up is a very complex and expensive endeavour and adoption of existing infrastructure, increase the likelihood of success. Examples of existing infrastructure include weather stations, mobile phone networks and satellite networks. Infrastructure that is in place for one purpose can often be used to serve an additional purpose/industry, such as GPS technology, which was originally only for military purposes. However, the ICT implementing agency must be careful with assumptions regarding the growth or improvement of infrastructure, whether by government providers or private players in the area.

Affordability and Simplicity

Many of the new ICT solutions require significant increases in bandwidth and computing power. The rural poor may however not be able to use such services because networks are inadequate or too expensive to use regularly. In addition, agricultural value chains are particularly complex ecosystems with many different players, often fragmented among many small players such as input suppliers, retailers or smallholder farmers. The simpler the ICT solution to implement and use, the less cost and the higher the likelihood of adoption.

Usability and Maintenance Capacity

It is necessary to think about not only the implementation phase of an agro-based ICT solution, but also how the solution will be maintained, especially if the promoting agency will not be present in the long term. It will often be necessary to bring on technical expert partners (preferably based locally), hard-ware and software vendors and, possibly, systems integrators to help ensure that the solution is implemented and maintained well. Those with few resources might do well to partner with larger, private companies, to take advantage of not only their technology infrastructure but also their expertise and general support.

Scalability, Replicability and Viability

Successful agricultural value chain ICT projects are generally successful when the fixed costs can be spread across wide usage of the technology. For instance, when there are many users, frequent usage and perhaps different types

of usage. Ideally, a solution initially tested and used in one type of geographical area should be easily implemented in another, with relatively low incremental costs. The issue of scale feeds directly into the issue of viability. Self-sustaining models with a clear revenue generation plan and/or financing model have a greater chance of success than those based solely on donors. If the solution does not generate revenue directly, clear and monitored cost and efficiency gains should be stipulated and tracked. Practitioners may do well to begin their endeavours with a clear for-profit and scaling strategy in mind or even with a for-profit partner that views the endeavour as a true business opportunity and not just a corporate social responsibility exercise.

4.1.2 SUB-MODULE 2: ICT TOOLS THAT SUPPORT DECISION MAKING IN AGRICULTURE

Lives and livelihoods of the world's most vulnerable communities rise and fall with fluctuations of agricultural production. As such, promoting the ability of smallscale farmers to access necessary knowledge, useful networks and support institutions through eLearning platforms can help improve agricultural productivity, safeguard food security, and create employment opportunities. It is for this reason that this sub-module highlights a few ICT tools that farmers and other agricultural stakeholders can leverage on to make informed decisions on value-chain selection, production, value-addition and marketing.

KIAMIS

Kenya Agricultural Market Information System (KAMIS) is a web platform that was developed to provide farmers and agricultural value chain stakeholders with improved early warning marketing and trade information. KAMIS makes transactions in trade between food surplus and deficit regions more efficient and competitive. It specifically provides farmers/stakeholders with advisories on Livestock and Crops Markets in terms of:

- Prices of commodity on different markets
- Commodity supply volumes, wholesale and retailing prices
- Major markets by County
- Cross border market information: trade volumes, commodity source and destination

KAOP

Kenya Agricultural Advisory Platform (KAOP) is an integrated online platform that uses geo-data from satellites to generate real-time and location specific agro-weather advisories to farmers and other stakeholders.

DigiFarm

DigiFarm is a FREE Safaricom service that offers farmers convenient, one-stop access to quality farm inputs at discounted prices, input loans, learning content on farming as well as access to market. Other value-add services provided through DigiFarm include insurance yield cover and extension services through remote agronomists located at the DigiFarm call center or on ground DigiFarm Village Advisors (DVA).

eLocust3m

eLocust3m is an application for smart phones that captures data about Desert Locust presence, bioecology and control operations. The information is used by agricultural stakeholders in real-time reporting and spatiotemporal mapping to support situation analysis and forecasts of future development for early warning and appropriate response. The rollout of eLocust3m app supports the Ministry of Agriculture (MoA) with timely information that covers the entire country.

M-Farm

One of the most familiar apps among farmers in Kenya, M-Farm which links farmers with local buyers across the country. It also offers important information by providing price trends to determine the best time to plant various commodities. Once the produce is ready M-Farm connects the farmer with thousands of ready buyers for the most ideal price.

iCow

iCow application offers permanent access to highly credible and verified agricultural information and data in a reliable, cost-effective and simple design accessible through an SMS alerts subscription or access to specific farming

needs on a 24-hour basis. From an evaluation study, iCow promoters have discovered their large trove of information was capable of enhancing yields and boosting incomes from crops, milk production, egg and poultry farming as well as lowering livestock mortality and improving soil fertility from as short as 90 days.

Agrobase

Agrobase application is made with agronomist and farmers in mind. The Application provides a database with agronomic information on weeds, diseases and pests, including diverse pesticides, herbicides and pesticides details from the selected countries. Allows farmers to identify pests, insects and diseases early enough to guarantee crop production and protection. The app has been used widely by livestock, horticultural, nut, fruit, vegetable farmers to protect their investment and accomplish higher returns. Constantly updated database offers links to solutions of identified problems, including detailed descriptions of the issues with accompanying photos.

VetAfrica

VetAfrica application was made for Android and Windows smartphones. It allows any farmer to record their livestock data in the process obtaining diagnostic guidance and advice on the most ideal treatment. The application offers a support system not just for livestock farmers but veterinary experts and animal health professionals. Information on various diseases is provided, such as Schistosomiasis, anaplasmosis, theileriosis, gastroenteritis and trypanosomiasis amongst others.

Urban Farming App

Urban Farming application shows people living in urban centres and thinking about farming how to grow vegetables with ease through constant interactive reminders. Your smartphone will constantly remind the user when the plants need some type of input such as fertilizer or water and how to solve the issue of crop diseases and common crop pests. Apart from information on growing organic and natural food from an urban home, delicious recipes are provided to prepare organic delicacies with ease.

Dairy Live

Dairy Live is a software for dairy farmers and professionals in the dairy industry around the world with a Kenyan reseller. The management application software allows farmers to work smart. Once they have fed information of all livestock and events such as pregnancy check, vaccinations, semen inventories and breeding. It allows farmers to instantly access livestock information wherever they are on a computer or smartphone. It also enables the farmer to create an event protocol that helps to track each animal's progress, track herd costs and computing returns. The app also comes with a server where the farmer can back up critical data. Standard charts will help you see how your herd compares with others regionally and nationally.

Breeding Wheel

One of the most critical details on a herd is identification of cattle with reproductive problems, service schedule, identifying animals with shorter lactation periods, cow drying date management, and calves' distribution, among others. The Breeding Wheel app allows farmers to access individual animal data from a dairy herd in form of a wheel. It also produces images of individual animals.

Digitization apps

Data is a critical asset in decision making process. There are therefore several tools that are available for data collection, organization and basic processing and visualization. Kobo Collect and Open Data Kit (ODK) are two of the most popular freely accessible data collection applications. These are open-source platforms for the collection of data using an Android Smartphones. Using the platforms, it is possible to collect structured questionnaires with rich data types including photographs, videos, numeric, textual and geographic information. They be used for the collection of baseline data as well as real-time and periodic monitoring.

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4.2 MODULE 2
CROSS-CUTTING ISSUES

Introduction

Cross-cutting issues are topics that are identified as important and that affect and cut across most or all aspects of development. These topics should therefore be integrated and mainstreamed throughout all stages of development from policy design, through implementation, to evaluation and learning. The key topics considered in this module of the guideline are; group dynamics, governance/leadership, gender, drug abuse, disability and vulnerable marginalised groups (VMGs). The following are the sub-modules:

- Group Dynamics.
- Governance/Leadership.
- Gender and Gender Mainstreaming.
- Drug abuse.
- Disability/ Vulnerable Marginalised Groups (VMGs).

4.2.1 SUB-MODULE 1: GROUP DYNAMICS

Introduction

Group dynamics deals with the attitudes and behavioural patterns of a group. Group dynamics concern how groups are formed, what is their structure and which processes are followed in their functioning. Thus, it is concerned with the interactions and forces operating between groups. Group dynamics is relevant to groups of all kinds that are both formal and informal. In an organisational setting, the term groups are very common and the study of groups and group dynamics is an important area of study.

A group is a collection of individuals who have regular contact and frequent interaction, and who work together to achieve a common goal(s). In the context of farming, a farmer group is a collection of farmers with a common objective or problem to solve, which is often associated with the production and marketing of agricultural produce/ products. A group may consist of as few as two (2) people or as many as 300 or 400. There are two types of groups, namely: **formal** and **informal**. The formal groups are structured to pursue a specific task while the informal groups are those that emerge naturally in response to organisational or member interests.

Formal groups

There are three main formal groups that include:

Command Groups:

Command groups are specified by the organisational chart and often consist of a supervisor and the subordinates.

Task Groups:

Task groups consist of people who work together to achieve a common task. Members are brought together to accomplish a narrow range of goals within a specified time period. Task groups are also commonly referred to as task forces.

Functional Groups:

A functional group is created by the organization to accomplish specific goals within an unspecified time frame. Functional groups remain in existence after achievement of current goals and objectives.

Informal groups

Interest Group:

- Interest groups usually continue over time and may last longer than general informal groups.
- Members of interest groups may not be part of the same organisational department, but they are bound together by some other common interest e.g. Common interest groups (CIGs).

Friendship Groups:

- Friendship groups are formed by members who enjoy similar social activities, political beliefs, religious values, or other common bonds.
- Members enjoy each other's company and often meet after work to participate in these activities.

Reference Groups:

- A reference group is a type of group that people use to evaluate themselves. The main objectives of reference groups are to seek social validation and social comparison.
- Social validation allows individuals to justify their attitudes and values while social comparison helps individuals evaluate their own actions by comparing themselves to others.
- Reference groups have a strong influence on members' behaviour.

A group has a number of benefits that include:

- Groups of farmers can access services.
- Collective production, marketing and purchase of inputs.
- Farmer groups provide a forum to share experiences and learn from one another.
- Group pressure enhances or stimulates adoption of knowledge and change to improved practices.
- Increases farmers' opportunities for participation in development programs.
- Gives farmers a 'voice' which they may be used to influence policy.
- Attracts external support and easy access to loans (group guarantors).

Group formation

A group formation passes through five main stages namely: Forming, Storming, Norming, Performing and Adjourning stages as summarised below:

GROUP FORMATION STAGES				
Forming stage	Storming stage	Norming stage	Performing stage	Adjourning
1. Individuals come together and get to know each other, 2. Dependent on direction 3. Members are polite 4. Introduction and sharing of information 5. Stereotyping individuals based on first impressions 6. Conversations are about safe acceptable topics	1. Individual confidence may lead to conflict 2. Personal agenda setting 3. Success at this stage leads to a more focused group relationship 4. Can inhibit progression and even lead to failure	1. Behavioural standards and norms among group members established 2. Getting used to each other and developing trust	1. Successful completion of the other stages leads to significant progress 2. Members work towards a common goal on a highly efficient and cooperative basis.	1. Individuals leave the group or the group dissolves on completion of objective 2. Time for reflection and re-orientation

Characteristics of a group:

- Two or more persons (if it is one person, it is not a group).
- Formal social structure (the rules of the game are defined).
- Common fate (they will swim together).
- Common goals (the destiny is the same and emotionally connected).
- Face-to-face interaction (they will talk with each other).
- Interdependence (each one is complementary to the other).
- Self-definition as group members (what one is who belongs to the group).
- Recognition by others (yes, you belong to the group).

Factors affecting group behaviour:

The success or failure of a group depends upon so many factors namely:

- Group member resources.
- Structure (group size, group roles, group norms, and group cohesiveness).
- Group processes (the communication, group decision making processes, power dynamics, conflicting interactions, etc.).
- Group tasks (complexity and interdependence).

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4.2.2 SUB-MODULE 2: GOVERNANCE AND LEADERSHIP

Introduction

Leadership in governance is the willingness and ability to take ownership in a part of an organisation and to continually do what is best for the organisation. Leadership is about mapping out where you need to go to "win" as a team or an organisation; and it is dynamic, exciting, and inspiring. Yet, while leaders set the direction, they must also use management skills to guide their people to the right destination, in a smooth and efficient way. Leadership sets the direction and makes sure that it happens ... governance is the accountability for that.

Leadership in governance is the willingness and ability to take ownership in a part of an organisation and to continually do what is best for the organisation. Effective corporate leaders stand on a foundation of solid governance principles. They have a clear mission and vision for the future and align their decisions with them. Leaders in governance follow a specific strategy and help to create a corporate culture that's conducive to success. Employees who embrace these concepts will naturally develop leadership skills.

Leaders tend to have certain essential attributes. They practice excellent two-way communication. Also, they have strong emotional intelligence and team-building skills. They understand the competitive landscape well and are forthcoming with suggestions and solutions. Strong leaders also have empathy for others and know how to express it appropriately. It takes courage for leaders at every level to remain committed to fairness, transparency and doing the right thing despite changing or challenging circumstances. Courage in leadership is a skill that leaders can develop within their employees.

Other key attributes in governance leadership are team-building skills, empowerment, trust and a willingness to listen to suggestions with an open mind. A key tool in developing these attributes in employees is being available and willing to accept feedback Governance encompasses the system by which an organisation is controlled and operates, and the mechanisms by which it, and its people, are held to account. Ethics, risk management, compliance and administration are all elements of governance. The qualities of an effective team leader inspire the trust and respect of the team and stimulate production within the workplace. The qualities of a good governance or leadership include:

- A Clear Communicator.
- Strong Organisation Skills.
- Confident in the team.
- Respectful to others/ Focuses on developing others.
- Fair and Kind.
- Influential in core areas.

- Willing to delegate.
- Self-aware and prioritise personal development.
- Encourages strategic thinking, innovation, and action.
- Ethical and civic-minded.

Good governance should be a thread that runs throughout your organisation. Have you considered whether that statement reflects the culture of your organisation and the mind-set of your employees? A commitment to good governance fuels today's successful organisations. Strong governance leaders enable and promote the practice of modern governance within their companies. Having a modern governance outlook allows organisations to adapt quickly to changing times, so that they can endure and thrive. Recognizing strong governance leaders gives employees a sense of career satisfaction, creates a strong connection with the organisation, and builds trusts between them and their superiors.

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4.2.3 SUB-MODULE 3: GENDER AND GENDER MAINSTREAMING

Gender is defined as a social relationship between men, women, and youth that is determined by society. The relations refer to a complex system through which women, men, and youth socialise. These relations determine the role and access to power, access to resources and control over their use.

Gender mainstreaming means integrating a gender equality perspective at all stages and levels of policies, programmes and projects. Asset ownership, access and control of resources. Ownership defines to whom the livestock belongs and makes decisions pertaining to; access is the opportunity to make use of a resource, control is the power to decide how a resource is used, and who has access to it.

Gender mainstreaming ensures that policy making and legislative work is of higher quality and has a greater relevance for society, because it makes policies responds more effectively to the needs of all citizens – women, men and youths (girls and boys).

Principles of gender mainstreaming

- There are five principles of gender mainstreaming
- Gender-sensitive language
- Gender-specific data collection and analysis
- Equal access to and utilization of services
- Women and men are equally involved in decision making
- Equal treatment is integrated into steering processes.

Why is it important?

Gender mainstreaming ensures that policy making and legislative work is of higher quality and has a greater relevance for society, because it makes policies responds more effectively to the needs of all citizens – women, men and youths (girls and boys).

A good practice example of gender mainstreaming could be actions that lead to a positive change in:

- Policies.
- Strategies / approach.
- Advocacy efforts.
- Legislation.
- Research and other analytical work.
- Statistics- greater sex disaggregation, improved gender analysis of data, or identifying gaps in the data base.

Challenges of gender mainstreaming

The main institutional barriers affecting the gender mainstreaming process include;

- Lack of political goodwill from the government.
- The slow pace of developing gender policies by various ministries.
- Lack of sensitization of staff on gender related issues.
- Lack of adequate budget.
- Ingrained cultural and social norms.

Gender Empowerment

- Empowerment is about people - women, men and the youth - taking control over their lives; setting their own agenda; gaining skills; building self-confidence; solving problems; and developing self-reliance.
- No one can empower another: only the individual can empower him/ herself to make choices or to speak out.
- Institutions including international cooperation agencies do support processes that nurture self-empowerment of individuals or groups.

Gender Equality versus Gender Equity

- Gender equality means that women and men have equal conditions for realizing their full human rights and for contributing to, and benefiting from, economic, social, cultural and political development.
- Gender equality is therefore the equal valuing by society of the similarities and the differences of men and women, and the roles they play. It is based on women and men being full partners in their home, their community and their society.
- Gender Equity is the process of being fair to men, women and the youth
- To ensure fairness, measures must often be put in place to compensate for the historical and social disadvantages that prevent women, men and youth from operating on a level playing field.
- Equity is the means while Equality is the result.

Gender Analysis

- Gender analysis is the process of analysing information in order to ensure that development benefits and resources are effectively and equitably targeted to different gender categories.
- It helps to successfully anticipate and avoid any negative impacts from development interventions especially to women or gender relations.
- Exploring and highlighting the relationships of the different gender categories in society - by asking:
- Who does what?
- Who has what?
- Who decides? How?
- Who gains?
- Who loses?
- Which men?
- Which women?

Gender analysis allows the identification of critical issues and existing constraints facing specific target groups and

enables the articulation of effective development strategies to overcome the identified limitations. The ELRP employs the value chain approach as the framework for delineation of the different roles and responsibilities of men and women along the priority livestock value chains. In selected agricultural value chains, men and women perform various primary value chain functions, which include input supply, production, processing, storage, wholesale, retail and consumption. Secondary actors or ancillary workers perform secondary service roles that support primary functions, such as transportation, brokerage and service processing. Both men and women can undertake activities at either the primary or at the secondary level of a value chain.

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4.2.4 SUB-MODULE 4: DISABILITY AND VULNERABLE MARGINALISED GROUPS

Persons with disabilities (PWDs) is described according to the UN Convention on the rights of persons with disabilities to include those who have long-term physical, mental, intellectual or sensory impairments. Hence, in interaction with various barriers, may hinder their full and effective participation in society on an equal basis. The 2019 Kenya census recorded 2.2% of the population above five years of age had a disability, whereas the 2009 census recorded 3.8%. In 2019, 1.9% of men and 2.5% of women had a disability while in 2009, 3.7% of men and 3.9% of women had a disability.

A disability is any condition of the body or mind (impairment) that makes it more difficult for the person with the condition to do certain activities (activity limitation) and interact with the world around them (participation restrictions). The PWDs are entitled to a barrier- free and disability- friendly environment to enable them to have access to buildings, roads and other social amenities, and assistive devices and other equipment to promote their mobility. with disabilities in such manner as may be specified by the Council. The four major types of disabilities include physical, developmental, behavioral or emotional, and sensory impaired disorders.

Vulnerable and marginalized populations are groups and communities that experience discrimination and exclusion (social, political, and economic) because of unequal power relationships across economic, political, social and cultural dimensions. Vulnerable populations include the economically disadvantaged, racial and ethnic minorities, the uninsured, low-income children, the elderly, the homeless, those with human immunodeficiency virus (HIV), and those with other chronic health conditions, including severe mental illness.

Marginalized groups exist nearly everywhere. They are people who, for whatever reason, are denied involvement in mainstream economic, political, cultural and social activities. Marginalization – sometimes also called social exclusion – refers to the relegation to the fringes of society due to a lack of access to rights, resources, and opportunities. It is a major cause of vulnerability, which refers to exposure to a range of possible harms, and being unable to deal with them adequately. It can negatively impact individuals' physical, psychological and emotional health. Some but not all of these consequences may include feelings of anger, anxiety, fear, depression, self-blame, sadness, stress and isolation.

The four major types of disabilities include physical, developmental, behavioural or emotional, and sensory impaired disorders. However, an expanded list includes:

- Vision impairment (blindness/ low vision).

- Deaf or hard of hearing.
- Mental health conditions.
- Intellectual disability.
- Acquired brain injury.
- Autism spectrum disorder.
- physical disability
- Dwarfism.
- Leprosy cured persons.
- Locomotor disability.

Do disabled pay taxes in Kenya?

Persons living with disability are granted a tax exemption on their monthly or annual income. This exemption applies to the first KES. 150, 000 per month or for the first KES. 1.8 M per annum. The Government funds services (including direct financial assistance) to support disabled people. By providing these services, the Government helps to give disabled people the opportunity to live an ordinary life. Disabled people receive extra support from a range of government agencies. Women, the elderly, adolescents, youth, and children, persons with disabilities, indigenous populations, refugees, migrants, and minorities experience the highest degree of socio-economic marginalisation. Marginalised people become even more vulnerable in emergencies. A sample of the most common marginalised groups:

- Senior citizens.
- Racial/Cultural minorities.
- Military Combat Veterans.
- Persons of below average intelligence.
- Hearing, visually, and physically Challenged Persons.
- Persons with a serious and Persistent Mental Illness (SPMI)
- Persons with Cognitive Impairments.
- Gay, lesbian, bisexual, and transgender (GLBT).

Eight marginalised groups still fighting for the freedom to vote in

- People with limited mobility
- People without valid ID
- Individuals with felony convictions
- Individuals deemed “mentally incompetent”
- Undocumented immigrants
- Low-income individuals
- People experiencing homeless
- Indigenous communities.

Further Reading

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4.2.5 SUB-MODULE 5: DRUG ABUSE

The substance (Drug) abuse is increasing in Kenya and especially among the youth. Current statistics indicate that more than half of drug users are aged 10-19 years. Most studies done in the country indicate that the commonly used drugs are nicotine, alcohol and cannabis. The existing information shows that the most abused drugs in Kenya are alcohol and Cannabis sativa (bhang) which is grown in a few isolated parts of the country. But there are reports of somewhat isolated cases of; cocaine, mandrax, hallucinogens, amphetamines and solvents. Certain factors can affect the likelihood and speed of developing an addiction:

- Family history of addiction shows that drug addiction is more common in some families and likely involves genetic predisposition.
- Mental health disorder.
- Peer pressure.
- Lack of family involvement.
- Early use.
- Taking a highly addictive drug.

Some of the most common types of drug abuse include the following:

- Stimulant Abuse; are substances that cause physical and psychological functions to speed up.
- Cocaine abuse.
- Adderall abuse.
- Meth abuse.
- Opioid abuse.
- Heroin abuse.
- Prescription painkillers.
- Sedative abuse.

A recent study by the National Campaign Against Drug Abuse Authority, Kenya found that:

- Most respondents held positive attitudes toward consumption of illicit drugs: cigarettes (73%), alcohol (72%), and khat (54%).
- Nationally, current use was alcohol, 13%; cigarettes, 11%; and khat, 6%.
- Drug use among those age 15 – 24 was alcohol, 9%; tobacco, 6%; khat, 5%; and cannabis, 1%.
- The median age of first use of both alcohol and cigarettes was 9 years, while that of cannabis was 14 years.
- Awareness of hard drugs was 20% among participants aged 10 –14 compared to 70% for those aged 15 – 65.
- Seventy percent of substance abusers of age 15 – 64 had multiple sex partners, and 60% of all participants were unaware of available treatment and rehabilitation services.
- Schools (77%) and religious institutions (62%) were the main sources of information for those aged 10 – 14.
- Perceived harm for cocaine and heroin was 80% in urban areas versus 6% in rural areas.

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4.2.6 SUB-MODULE 6: AGRIBUSINESS

Investing in agriculture is an important strategy towards improving food and nutrition security; and rural incomes; reducing poverty; and promoting sustainable development. Financing agribusiness increases the added value of raw materials, strengthens rural economies and improves the quality of life in many vulnerable households. The majority of farmers in Kenya practice subsistence farming, producing both crops and livestock to meet their basic food requirements. The changing economic circumstances however dictate the need for additional finances to meet household demands and it is imperative that farmers deliberately engage in activities that generate income. Extension services should support farmers to embrace 'farming as a business' approach to improve earnings from farm activities, and eventually transition from subsistence production to commercial/agribusiness. This calls for appreciation and application of business principles in day to day farming decisions and operations.

Importance of Agribusiness

Agribusiness is a term used to describe the sector that encompasses all economic activities that are related to farming, i.e., chemicals, breeding, livestock/crop production (farming), farm machinery, distribution, marketing and sales. It refers to agriculture-related activities that put farmers, processors, distributors, and consumers within a system that produces, processes, transports, markets and distributes agricultural products. Financing agribusiness can increase the added value of raw materials, strengthen local rural economies, food security and nutrition, and improve the quality of life in many homes at risk of exclusion and vulnerability.

Entrepreneurship/ agripreneur is the ability and readiness to develop, organise and run a business enterprise, along with any of its uncertainties in order to make a profit. It is the creation or extraction of value. Entrepreneurship is viewed as change, generally entailing risk beyond what is normally encountered in starting a business, which may include other values than simply economic ones. Policies, incentives and regulatory frameworks that safeguard and promote agro-industries have proven to be highly effective at lifting rural populations out of poverty in many countries.

Farming as a business

Farmers seek to use as little of the meager elements of production as possible to maximize the production of most of the goods that are needed and or wanted - as dictated by the market price. Farming as a business also involves market considerations. Farming for the market is a business since farmers use land, labour, and capital (factors of production) to produce goods to be sold. Such farming is done in the hope and expectation of profit as in all other businesses

Crucial Business Principles

To succeed in farming business just like any other business, eight crucial principles should be applied. These are:

Develop a passion

Passion is the energy that drives the entrepreneur to success no matter the difficulties that may arise in any business including farming. Passion brings the entrepreneur back to farming even after losing chicken to a disease or when predators kill all his/her animals.

Commitment to continuous learning

Farmers needs to acquire and to build on new skills, information, wisdom, knowledge and understanding. A lot of information is available on media, on line seminars, training institutions, NGOs and government agencies.

Readiness to tackle problems as they come along

Successful farmers turn their problems into opportunities for growth and enhanced profits. Farmer face challenges and problems despite their level of preparedness. "Yes, Tough times never last but tough people do".

Application of sound business principles

Farming should be grounded in sound business principles for success and the entrepreneur must embrace "farming is a business concept". Thus, the entrepreneur should and must understand the market dynamics, obey the laws of demand and supply, and practice market timing.

Being a marketer

Farmers and entrepreneurs in Kenya today must adopt marketing skills to succeed in farming and there is no point of availing products which cannot yield returns. Good agribusiness business performance is determined by the ability of a farm to sell a product or service at a competitive price. Farmers should learn to participate in markets and seek market information to guide in planning production activities. Farmers can participate in markets through producer groups and organizations who provide marketing services including aggregation; storage; processing; transportation and provide market linkages.

Re-investing farming profits

Cash flow and profits are important elements of any business and business success requires continuous and sustained growth. Returns from business should be re-invested. A business plan integrating a growth strategy is an important tool to guide business expansion.

Healthcare

Life is important despite the problems that abound in any farming venture and it is said that "Health is wealth"! Farmers organizations in the coffee, tea and dairy sectors are promoting health insurance products and supporting their members to acquire medical services through group covers. Farmer's health needs to be constantly monitored through medical reviews and such insurance covers should be promoted to ensure a healthy farming community. Farmers should avoid stress and depression by participating in family health sensitization and training programs offered by various organizations at the local level. Agricultural insurance should be promoted since it takes away worries arising from uncertainties related to farming.

8. Enjoy what one does

Any business that cannot be taken as an adventure will ultimately burden the owner. Entrepreneurs need to learn and to enjoy the whole farming process. Farmers should embrace farming as an adventure - should be happy and optimistic to absorb profits and losses with their heads held high.

Importance of Agribusiness

Farming as a business focuses farmers' efforts towards getting the best out of their farm resources and optimizing their investments. This involves applying business practices such as; Record keeping; Benefit–cost/ gross margin analysis; Business planning and Business. It is imperative for farmers to acquire certain critical skills including; - Marketing skills, good communication skills, group management skills, gender considerations among others

Goals of farming as a business

To understand the importance of FAB, 5 farm goals should be clearly defined answering the five questions of: - what? how? Whom? When? How much?

What to produce (Enterprise issues)? Out of the many possible enterprises that can be carried out in a farm, the entrepreneur needs to identify what to produce to maximize profits from the available production resources.

How to produce it? (Technological issues). Is it possible to produce it on your land; What resources and inputs are needed and where to get them; What labour do you need? What production skills and information is needed? What combination of Inputs; Technologies, Innovations, Management practices (TIMPs)

For whom to produce?. What is the best/target market for the product? (Market/ marketing issues); For which market?

When to produce?. (Seasonality Issues/ Supply and Demand); What price can the product get in the market at the season; Is it profitable? Does the farmer have enough capital to produce at that particular time? What are the risks of producing at such a time; What to do about those risks?

How much to produce?. (Economies of scale/ Returns to scale) Where is the business going – in terms of expansion and growth? What needs to be done?

Farm Business Planning

It is important for a farmer to understand what a business plan is, why the farmer needs it and how it is prepared. Planning is preparing a sequence of action steps that will assist the agripreneur to achieve specific goals. It is a road map that shows where one wants to go and how to get there. Farming as a business is not business as usual and calls

for entrepreneurship.

Importance of a Business Plan

A comprehensive and creative business plan is a critical tool for an entrepreneur. The business plan is important in ensuring the following: -

- Entrepreneurs concretize ideas and serves as a road map
- Guides the farmer to make the best use of his/ her meager resources.
- Minimizes unstructured actions which cost more because the farmer moves back and forth.

Steps in Farm Business Planning

- Set a goal, that is, determine where you want to go. The goal must be SMART, List the objectives to be achieved.
- List the activities to be undertaken under each objective.
  For each activity specify the person responsible and the time froad terms e.g. an activity may require the hiring of labourthat is needed.
  Next indicate the resources needed to undertake each activity in brr, purchase of breeds, feeds, seedlings etc.
  State specific date during which the plan implementation may be reviewed. Remember: Failing to plan = Planning to fail

Farm Business Plan Format

- Executive Summary – Provides a concise overview of the entire plan; shows current position of the business and where the owner wants it to be in the future.
- Business Description – Shows the business registration and background
- Marketing Plan – This shows the market analysis, customer needs, their location, and how to reach them.
- Operational Plan – Thus sets out the work to be carried out and the work flow from initial input to end results and all the needed resources
- Financial Plan – It should include Profit and loss statement; Cash flow statement; Balance sheet; Sales forecast; Personnel plan; and possibly some business ratios and/or a break-even analysis

Regulatory and legal requirement – Adherence to government regulations

Farm budgeting. Budgeting is the process of forecasting the business entity's costs and income for a particular period of time and estimating the future outcome of a plan, normally based on a cycle. The budgeting entity can be an individual, a business, a group or a government. In the context of farming, budgeting is a process of analyzing plans for the use of agricultural resources at the command of the decision maker for an intended outcome.

Types of Farm Budgets

Whole farm budget: This combines all the enterprises and resources of the farm to provide an overall picture of the expected net returns for the period.

Gross Margin/ Enterprise budget: It estimates costs and returns expected on each enterprise and for comparisons

Partial Budget: This is a planning tool adopted to analyze relatively small changes in the whole farm by looking at only income and expense items that will change and not total values

Cash flow budget: It forecast the movement of money into (cash inflows) and out (cash outflows) in the farming business over a given period of time.

Steps in Preparation of Farm Business Budget

Defining a production Program - Livestock and or Crops.

Estimating and specifying the input requirements - Estimate the input requirements for each operation and the cost of inputs.

Estimating the cost of production - Estimate the all the production processes anticipated e.g. for maize - Land

preparation, planting, weeding, harvesting and marketing.

Estimating the quantity and value of output - Estimate the anticipated quantity and value of output based on the average yields and prices.

Compare the costs and returns to determine the net returns - Compare the anticipated costs and the returns to determine the net returns.

Uses of farm budgets

- Decide what to produce; how much to produce; and the resources needed.
- Itemize the financial aspects of the farming business.
- List the inputs and production practices required by an enterprise.
- Evaluate the performance of different farm enterprises.
- Estimate benefits and costs of changes in production practices.
- Provide the basis for a total farm plan.
- Show the capacity of the farming business to carry risk.

Farm records and record keeping

Farm records include livestock breeds reared; individual livestock records; crops cultivated; inputs; varieties planted; management and operations activities carried out; quantity harvested/ produced; and marketed. Records may also include minutes of a meeting on the farm. Record keeping involves gathering valuable data or information on the farming activities of a particular enterprise. This is done with the view of processing it in the future (for example, analyzing sales and costs and calculating profits). The record keeping format adopted should be simple and easy to implement, without compromising the quality of the records

Records provide essential information for Proper farm planning; Credit sourcing; Monitoring farm performance; and Provide basis for decision making. Records also provide insight into farm expenditures and receipts including proceeds from the sale of produce. Records guide in making sound decisions in determining what to buy and sell. Keeping records of cash and credit transactions of purchases and sales ensures no losses are incurred.

Commercial farming involves many transactions, which call for accurate and up to date book/ record-keeping to determine if a profit or a loss was made.

Books of accounts

Books of account are records of business transactions. Simple accounting systems should be designed to provide information efficiently and quickly at least cost as well as capable of offering protection to the business by exposing theft or fraud. It is important to record and keep all the source documents (sales and purchase receipts/ payment vouchers). The accounting records should be entered in journals and processed through ledger books to generate financial statements (Balance sheet and Income statement).

Gross Margin (GM) Analysis

Gross Margin (GM) refers to the gross return after all variable costs have been accounted for, which means it is the return on variable costs only, and does not include fixed costs. GM is the difference between the Gross Farm Income (GFI) and the Total Variable Costs (TVC) of a given farm enterprise. Thus, GM = (GFI – TVC)/farm unit (acre/ hectare). Enterprise GM calculation requires sequential analysis of various activities, so that all input requirements and related costs are determined. This requires complete farm records of various activities involved in the production of each specific farm enterprise.

Markets and marketing

A market is a physical place where the exchange of goods and services takes place. It occurs as a result of buyers and sellers being in contact with one another, either directly or through mediating agents or institutions. It may or may not be a physical location. It is a place where buyers and sellers meet to exchange goods, services and other relevant information. In essence, a market refers to the set of all actual and potential buyers of product and services and the accompanying transactions.

Marketing refers to a series of activities involved in making available services and information which influence the desired level of production, relative to the market requirements and the movement of products from the point of production to the point of consumption. The marketing process involves collection, analysis and dissemination of the desired market data. Marketing refers to the process through which the gap between the producers and consumers is bridged. In this definition, producers are separated by both distance and time. Marketing involves finding out what the consumers want and then supplying them with the same at a profit.

Market and Marketing Terminologies

Need: It means a state of felt deprivation of some basic satisfaction, e.g. one needs food, air, security.

Want: This is a desire for a specific satisfaction of a need – one may need clothing but specifically wants a jean i.e. from general (need) to specific (want).

Demand: It means "the "want" for a specific product backed by the ability and willingness of the buyer to buy that specific product.

The 5 P's of marketing namely; Product, Price, Promotion, Place, and People also known as the marketing mix provides a framework that guides marketing strategies and keep marketers focused on the right activities. Agribusinesses need marketing strategies to ensure consumers wants and satisfied and demand is sustained.

Marketing functions

There are four main functions in the process of marketing:

Transportation

Transport reinforce and strengthens trade operations. Agricultural commodities as well as farm inputs must be transported from their initial point of produce through the marketing channel to the final consumer. Transport in agricultural marketing plays very important roles:

Markets would be localized in certain areas without transportation of goods from one place to another.

- Exchange of goods between regions and countries would be impossible in the absence of this function.
- Transportation narrows price difference over space – distance between producing areas.
- Transportation widens the market by bridging the gap between producers and consumers located in different areas.
- Transportation of goods from areas of production to areas of scarcity balances prices in the two regions.

Grading and Standardization (also called transformation function)

Grading means sorting of unlike lots of the produce into different lots according to customer quantity specification. Agricultural commodities are graded according to certain characteristics such as weight, size, appearance, texture, moisture content, length, taste etc. Two types of grading are agricultural produce/ commodities:

Fixed grading. Refers to sorting of commodities according to standard or characteristics which are fixed and do not change with time.

Variable grading. This refers to the grading standards which may change over time i.e., the standard changes every year depending on the quality of produce that year (esp. for agricultural products)

Storage Function

Storage is an important marketing function which involves holding and preserving goods from the time they are produced until the time they are consumed. Agricultural produce may require aggregation and storage as a result of surplus production and the need to sell at the right time and price.

The storage function of agricultural produce is necessary because it balances supply and demand for agricultural

and food products. Agricultural production in developing countries is usually seasonal whilst demand is generally continuous throughout the year, hence the need for storage to smoothen supply.

Processing Function:

The Processing function is defined as a deliberate activity which changes the form of a good. Processing function converts farm products into a more useful form. Farm products require some form of processing to improve the shelf life and ensure quality throughout the marketing channel. Some produce e.g. eggs, fruits & vegetables can be consumed directly in the form in which they are obtained from the produce. Kenya government regulations require milk to be processed before consumption to ensure health standards are maintained.

4.6.7 SUB-MODULE 7: AGRICULTURAL INSURANCE

Risk is an important aspect of the farming business and arise from a variety of sources. Farming businesses operate in a rapidly changing and unpredictable environment that impacts upon the outcomes of investment activities. The uncertainty associated with climate variability is a disincentive to investment, adoption of agricultural technologies and response to market opportunities.

Climate risk insurance for developing countries aims at reducing the economic risks of people. Insurance can buffer at least the financial implications of extreme weather and climate events through its risk transfer role. Currently, most public private programmes in developing countries offer livestock insurance and crops. Insurance can spread and smoothen the risk, may allow farmers to recover faster and more efficiently, provides certainty about post-disaster.

Weather index insurance is one of the possible interventions for overcoming the negative impacts of climate risk on rural livelihoods and agricultural production. Index insurance is normally linked to rainfall anomalies (drought, floods), extreme temperatures and humidity (frosts, hails), or even livestock/ crop yields. The use of a weather index linked to an insurance mechanism is a market-driven solution. It calls for a public-private partnership and the development of the private sector for its success.

Areas to be covered

- Sources of risks in agriculture
- Strategies for risk management
- Informal risk management strategies
- Formal risk management strategies
- Types of agricultural - livestock insurance
- Types of livestock insurance products
- index insurance
- Benefits of livestock/crop insurance and index insurance for a farmer
- Livestock/crops cover
- Livestock/crops insurance program
- Why focus on agricultural insurance?
- Features of agricultural livestock/crops insurance
- Risk financing instruments

Sources of risks in agriculture

Risk is defined as the probability of occurrence of hazards and shocks that negatively impact agricultural production, trade, markets and consumption. Risk and uncertainty are inherent to agriculture. The most common sources of risk are weather; climate; diseases; natural disasters; government policies; changes of prices in agriculture products to fertilizer and other inputs; financial uncertainties; global markets and environmental shocks. Farmers face a number of interconnected risks and the uncertainties can cause wide swings in yields and farm income.

Agricultural risks have been grouped into five categories and need to be addressed in order to stabilize farm income

namely: production, marketing, financial, legal and human resource risks.

Production Risks

Production risks relate to the possibility that your yield or output levels will be lower than projected. Major sources of production risks arise from adverse weather conditions such as drought, freezes, or excessive rainfall at harvest or planting. Production risks may also result from damage due to insect pests and disease despite control measures employed, and from failure of equipment and machinery such as an irrigation pump.

Marketing Risks

Marketing risks relate to the possibility that you will lose the market for your products or that the price received will be less than expected. Lower sales and prices due to increased numbers of competing growers, over supply and/or changing consumer preferences are common sources of marketing risk. Marketing risks can also arise from loss of market access due to a wholesale buyer or processor relocating or closing, or if a product fails to meet market standards or packaging requirements.

Financial Risks

Financial risks relate to not having sufficient cash to meet expected obligations, generating lower than expected profits, and losing equity in the farm. Sources of financial risk commonly result from production and marketing risks described earlier. In addition, financial risks may also be caused by increased input costs, higher interest rates, excessive borrowing, higher cash demand for family needs, lack of adequate cash or credit reserves, and unfavourable changes in exchange rates.

Legal and Environmental Risks

In part, legal risks relate to fulfilling business agreements and contracts. Failure to meet these agreements often carry a high cost. Another major source of legal risk is tort liability - causing injury to another person or property due to negligence. Lastly, legal risk is closely related to environmental liability and concerns about water quality, erosion and pesticide use.

Human Resource Management Risks

Human resource risks pertain to risks associated with individuals and their relationships to each other. These relationships include those with family members, as well as farm employees and customers. The impact of any of these events can be devastating to a farm. Human resource risks also include the negative impacts arising from a lack of people management skills and poor communications.

Strategies for Risk Management

Managing risk starts with identifying the most crucial risks; understanding the potential impacts and likelihood of undesirable outcomes; and, identifying and taking possible steps to mitigate or lessen the impacts. Risk management cycle involves; - risk analysis; risk prevention and mitigation; building on preparedness; risk transfer; risk response; building resilience and recovery, It is unlikely that an individual farmer understands all the areas of risks faced in a farming business. Farmers need advisory services on risk management (Figure 4.1) which can be sought from bankers, insurance agents, and other service providers. The management of risks calls for innovative approaches for improving the resilience of rural households and leveraging finance and investment. Farming businesses need to be pro-active and enhance capacity to assess, prepare, absorb and adapt to risks. The risk management interventions should build resilience in the farming households and result in sustainable development.

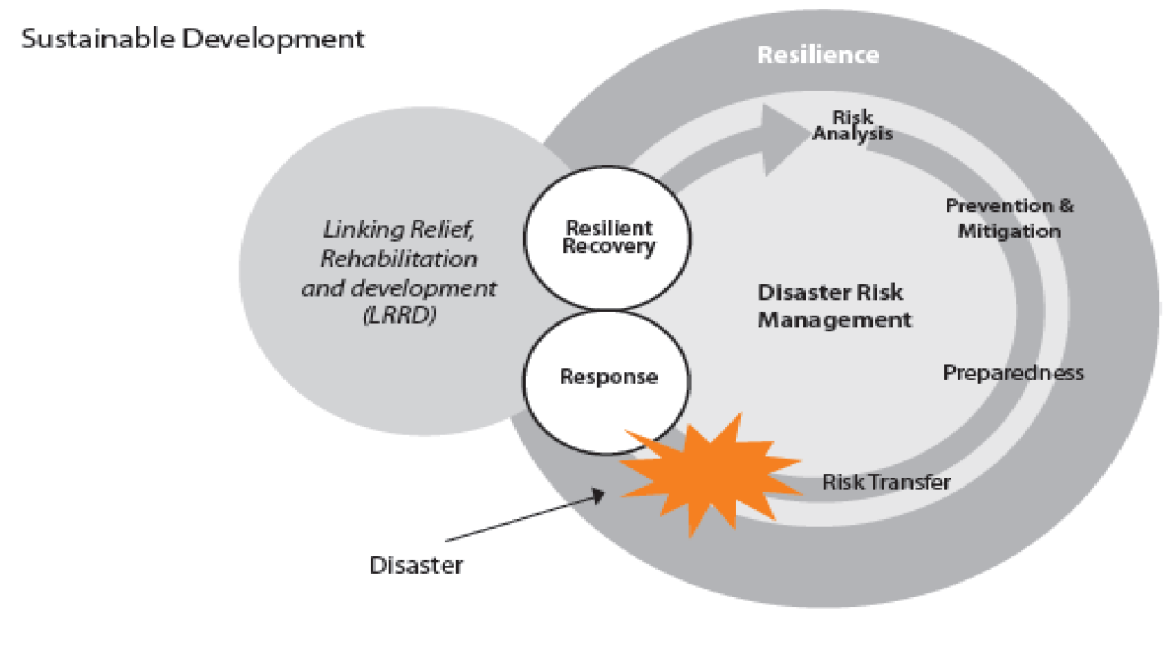

Figure 4.1. Risk management process…….

There is no single solution for managing agricultural risks and the commonly used **strategies include:** Livestock and Crop Insurance; Enterprise Diversification; Contract Production; and application of Climate Smart Technologies, Innovations, Management Practices.

Informal Risk Management Strategies

Farmers use a combination of informal innovations and techniques that lead to risk mitigation.

- **On - farm Risk Management Techniques** include:- irrigation; crop diversification; conservation agriculture techniques – zero tillage; crop protection/ pest control; and herd shifting.
- **Self-insurance tools ;-** savings; income diversification; asset accumulation; and emergency informal credit - family and chamas.

Formal Risk Management Strategies

Various risk management strategies exist and are applied depending on the scenarios.

- ***Low risk investments*** **-** avoiding high risk endeavours.
- ***Enterprise diversification*** - investing in a variety of less than perfectly correlated investments within a portfolio - reduces variability of returns; allow mean returns to be maintained.
- ***Excess debt capacity*** **-** maintain relatively low debt-to-asset ratios - mitigating financial risk (because of the seasonal nature of production and, hence, revenue generation).
- ***Liquid financial reserves*** **-** liquid assets to help mitigate seasonality effects and reduce financial risk including the risk of crop failures.
- ***Off -farm income*** **-** provides a more stable and, potentially, non-seasonal source of income.
- ***Shared ownership or leasing*** of productive assets - land, buildings, livestock, and machinery - partly or wholly owned
- ***Risk Transfer*** - shift risk from producers at cost – insurance products; contracts; commodity futures markets

Why focus on agricultural insurance?

Agriculture dependents on physical and market conditions that are uncertain and agricultural entrepreneurs and farmers have to expect, accept, and manage risks to maximize outputs?s and minimize losses. Farm business operators need to be risk conscious in order to avoid devastating losses. The importance of agricultural insurance cannot be

underscored given the significant contribution of agriculture to the economic and social life of rural communities.

Climate volatility represents an important aspect of agricultural production and presents major risks to the outcomes of farm investments and thwart agricultural productivity gains especially in the face of climate change. The uncertainty associated with climate variability is a disincentive to investment, adoption of agricultural technologies and response to market opportunities. Physical climate risks are either acute or chronic. Acute risks include droughts, floods, extreme precipitation and wildfires. Chronic risks include rising temperatures, the expansion of tropical pests and diseases into temperate zones, and an accelerating loss of biodiversity. Agricultural insurance serves as a reliable risk mitigation instrument for coping with climate-related hazards.

caption

Types of Insurance Products

Agricultural insurance is a valuable financial instrument for smallholder farmers. It increases their resilience by avoiding or limiting potentially devastating financial losses and protects farmers from falling into poverty. Insurance also eases access to finance and increases smallholders' productivity. Farmers can confidently invest in enterprise improvement and adopt new technologies that provide increased income and eventual graduation from poverty. Insurance companies in Kenya have developed a variety of products targeting both livestock and crops enterprises.

Crop Insurance Products

- **Area Yield-Based Index Insurance (AYII) -** This is a multi-peril micro-insurance product rolled out by the Government of Kenya together with other collaborating insurers. It covers smallholder maize and wheat farmers against poor yields due to poor weather and natural catastrophes.
- **Weather Index-Based Insurance (WII)** - This product compensates farmers for crop damage as a result of deficit or excesses in weather conditions such as temperature, sunlight, wind speed or rainfall resulting in losses during the length of the crop growth cycle up to physiological maturity.

At the end of each growing season, the weather data collected is automatically compared to an index of historical weather data. If the season's rainfall was, for example, 15% above or below the average, the insurance pay-out owed

to client farmers is processed and paid.

Benefits of insurance and weather index for a farmer

- **Peace of mind**. when individuals have insurance in place to deal with the financial burden of losses from insured risks, they are encouraged to invest more in their farms.
- **Risk transfer**. Insurance does not prevent losses from occurring. The primary function of insurance is to transfer the financial consequences of an insured risk to an insurance company.
- **Risk pooling**. Insurance gathers together people who want insurance protection and creates a pool from which contributions of the entire pool compensate the unfortunate few who suffer from loss.
- **Objective measure of loss**. The weather is easy to observe and provides an objective trigger for the insurance payout. Weather events affect large areas simultaneously, index insurance is a good tool for helping farmers farming in similar region.
- **Fast claims process**. Payouts are calculated automatically for all insured farmers under one reference station – there are no claims to file.
- **Preservation of source of income**. Pay outs come quickly to provide compensation when you need it hence improving sustainability of crop production.
- **Boost access to credit**. Financiers are more willing to offer credit because with weather index insurance their risk has reduced. Insurance may also enable contract farming. An agricultural marketing company contracting farmers would be interested in securing continuity of production for their farmers. They identify the crops key risks and would encourage their farmers to protect their inputs and potential harvests against the identified risks

Benefits of livestock insurance

The benefits of Livestock insurance include:

- Enables pet owners to save money when their pet is injured or ill.
- Empowers pet owner to not have to choose between their financial stability and their pet's life.
- Enables pet owners to focus on the health of their pet, rather than the costs of their care

Key Points on Index Insurance

- Index insurance builds resilience and contributes to adaptation both by protecting farmers' assets in the face of major climate shocks, by promoting access to credit, and adoption of improved farm technologies and practices.
- Index insurance triggers pay outs based on an index (e.g., rainfall, remote sensing) that is correlated with losses, rather than actual losses, eliminating costly farm visits to verify losses, reducing administration costs, lowering premiums, and providing more timely payments.
- Weather insurance only covers losses related to a specific weather index - other non-weather risks like pests and disease are not covered
- Pay outs are based on the weather observed at the local weather station, not at the farm. If rainfall is different at the farm than at the weather station, the farmer may not receive a pay out even if he experienced a drought or excess rain that damaged his crop.
- Pay outs come quickly to provide compensation when you need it
- There is a cost, premiums. Premium is paid in advance and are non-refundable. Premium covers one season and is not carried over to the next season if there is no payout
- Weather insurance can improve sustainability of crop production using the payout to purchase inputs after a poor season
- Financiers are more willing to offer credit because with insurance reduces their risk.

Livestock Insurance Products

Insurance companies understand that farmers' livestock form part of their income generating activities. They offer insurance cover for high value animals (dairy or beef) losses/death as a result of; accidents, illness and disease, epidemics, emergency slaughter and calving risks. The companies cover farmers' cattle; dairy and beef from– 3 months to 10 years, sheep and goats from– 2 months to 7 years. It can be extended to cover; Transit risks, Theft cover as well as Loss of income benefit. Livestock insurance covers against losses to animals.

While these policies are usually meant for standard farm animals like horses, poultry, and cattle, they can also cover losses of exotic and aquatic animals. These policies pay to replace livestock that dies, has to be put down, or is stolen. The insurance company will pay the owner of the animal should the animal die in any of the following circumstances;

- Some insurance companies understand that farmers' crops/livestock form part of their income generating activities
- They offer a cover for high value animals and crops (dairy or beef/ horticultural crops) losses/death as a result of; accidents, illness and disease, epidemics, emergency slaughter and calving risks.
- The companies cover farmers' cattle; dairy and beef from– 3 months to 10 years, Sheep and goats from– 2 months to 7 years.
- It can be extended to cover; Transit risks, Theft cover as well as Loss of income benefit. Livestock/crops insurance covers against losses to animals and/or crops.
- While these policies are usually meant for standard farm animals like horses, poultry, and cattle, they can also cover against losses to exotic and aquatic animals. These policies pay to replace livestock that dies, has to be put down, or is stolen
- The insurance company will pay the owner of the animal/ crops should the animal die or crops be destroyed in any of the following circumstances for livestock;
- **Accidents:** lightening, internal and external injuries, windstorm, snake bite, electrocution or flooding
- **Illness or disease:** any animal illness or disease
- **In shoats:** Rinderpest, Blackquarter, Hemorrhagic, Septicemia, Anthrax and Food and Mouth Disease, Enterotoxaemia, Sheep Pox, Goat Pox, H.S.B.O.
- **Epidemic:** Widespread outbreak of an infectious disease affecting many animals at the same time in a region
- **Emergency slaughter** on advice of qualified veterinary surgeon following an accident, illness or disease
- Calving, farrowing and kidding complications leading to death of insured animal

These diseases are covered by the policy if the animal is successfully inoculated (protected) and necessary Veterinary Certificates are supplied to the Company

Successful Kenya Livestock Insurance Program scheme scales up

- Approximately 75% of livestock deaths in the Horn of Africa are caused by severe drought, repeatedly leaving herders, their families and entire communities destitute.
- In October of 2015, the first government livestock insurance scheme in Africa – the Kenya Livestock Insurance Program (KLIP) - was successfully piloted in two counties in the North of Kenya.
- The scheme, which was launched with the support of Andrew Mude, ILRI, 2016 winner of the World Food Prize Award, and Swiss Re, will now be scaled up to benefit herders across the country.
- The programme applies satellite-based index insurance to protect pastoralists in remote areas. Satellites assess the state of the grazing conditions in a certain region by measuring the colour of the ground.
- Green is good while yellow is very dry. Once a certain threshold is reached the insured automatically receive a lump sum payment, allowing them to provide their livestock - which includes cows, goats and camels – with feed and water, to survive.
- The fact that KLIP is designed to keep livestock from dying, allows the pastoralists to hold on to their way of life and means of survival.

Importance/contribution of Agricultural Insurance to climate resilience

- Increases households or farmer's willingness to invest in CSA technologies
- Improve farmers' access to credit for agricultural activities.
- Supports agricultural and rural development by helping households, financial service providers and input suppliers cope with low-to-medium episodes of covariate risks, for example, drought or excessive rainfall.
- Provides an alternative method of financing disaster reduction assistance or relief programmes.
- High participation in agriculture insurance reduces the need for ad hoc disaster programs which tend to be expensive, ineffective, and inefficient.
- Indirectly curbs emigration from rural areas into urban regions - migration increases in years of low farm production. Agricultural insurance hedges against income disparities and improves producer well-being.

Risk Financing Instruments

It is important to note that numerous non-financial regulation or low-cost solutions are available within Climate Risk Management framework for sustainable development. However, sufficient funding before and after a disaster is necessary. Often, disaster risk financing and insurance-based solutions are criticised for not contributing to prevention and mitigation directly. The availability of funds immediately after a disaster can alleviate this effect.

Summary

- The ongoing risk of climate change (CC) is one of the many challenges facing Kenya's farmers' today.
- Insurance-related instruments can support the protection and promotion of sustainable development and human rights.
- Careful implementation and management through a comprehensive risk management and risk reduction strategy is needed
- Initiatives are needed to create a conducive enabling environment which encourages innovation, investment, and action.
- The right policies and incentives need to be in place so that the challenges imposed by CC on food systems can be addressed

Further Reading

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