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MESPT
MICRO ENTERPRISES SUPPORT PROGRAMME TRUST

MINISTRY OF FOREIGN AFFAIRS OF DENMARK
Danida

Banana Value Chain Manual

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Disclaimer

This manual is for advisory use only. Users of this manual should verify details that relate to their agro-climatic zones from their area agricultural extension officers. It is also advised that this training manual should be used in conjunction with the respective value chain handbook and other relevant resource materials.

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Published by

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Foreword

The Micro Enterprises Support Programme Trust (MESPT) is a local development organization founded in 2002 through a partnership between the Government of Kenya (GoK), the European Union (EU), and later, the Royal Danish Government. MESPT's main goal is to eradicate poverty by supporting the growth of micro-enterprises, including agricultural production, agribusiness, and afro-processing. This support aims to foster social, economic, and environmentally sustainable growth by increasing access to financial and business development services, creating jobs, and promoting sustainable micro-enterprises. Our vision is to build a more prosperous society, and our mission is to provide sustainable business development and financial services to smallholder farmers and agri-MSMEs in Kenya.

For over two decades, our team of professionals has been at the forefront of developing cost-effective and scalable solutions that promote financial inclusion and support the growth of sustainable agribusinesses. We accomplish this by providing tailored financial solutions that meet the specific needs of various agricultural value chains, delivered through a wholesale lending model to financial service providers such as SACCOs, MFIs, and Farmer Cooperatives. These providers, in turn, extend loans to smallholder farmers and micro agricultural enterprises.

Our approach emphasizes delivering integrated financial and business development services to smallholder farmers and MSMEs in Kenya, helping them access finance, boost agricultural productivity, improve afro-processing and connect to markets. Over the years, we have worked closely with county governments, development agencies, donors, and investors to strengthen business development capacities in the agricultural sector, using a unique tripartite model that connects farmers, SMEs, and financial institutions.

Banana is among key value chains that have been supported by MESPT over the years through various interventions in order to enhance commercialization. MESPT appreciates the importance of documenting best practices for the value chain in facilitating effective delivery of training for farmers and Agri-preneurs. Therefore, MESPT has facilitated the development of this manual alongside the value chain trainers' guide and other resource materials through Green Employment in Agriculture Programme (GEAP) with support from DANIDA.

This guide is expected to enhance effectiveness in delivery of trainings on Good Agricultural Practices and commercialization of the value chain. I am optimistic that this manual will be helpful to partners in the value chain including county governments. I am grateful to DANIDA for the continued support to MESPT programmes. I am also thankful to the value chain experts who spearheaded compilation of this manual.

Rebecca Amukhoye,

Chief Executive Officer, Micro-Enterprises Support Programme Trust

Preface

The Green Employment in Agriculture Programme is a 5 years' programme (2021 to 2025) funded by DANIDA and implemented by Micro-Enterprises Support Programme Trust (MESPT). GEAP seeks to contribute directly to Kenya's vision 2030 and to one of Denmark-Kenya Strategic Framework on accelerated decent employment creation in MSMEs and improved competitiveness of targeted value chains in agriculture which will contribute to transforming the economy towards a greener and more inclusive growth.

GEAP programme targets 40,000 smallholder farmers and will be implemented in 12 counties namely, Kilifi, Kwale, Nakuru, Nyandarua, Siaya, Kisii, Kakamega, Bungoma, Trans Nzoia, Uasin Gishu, Makueni and Machakos. The programme facilitates increased commercialization, decent employ-ment, and green transformation through targeted interventions in selected agriculture value chains that include, Cassava, Coconut, Dairy, Export Vegetables, Pineapple, Indigenous Poultry, Moringa, Pineapple, and Aquaculture.

MESPT through GEAP tasked multidisciplinary teams to develop resource materials tailored for extension service providers and farmers. This Banana value chain manual is one of the series of the materials that were developed. MESPT further tasked value chain experts to develop a value chain trainers' guide for Banana. This manual is to be used as a reference material for training on implementation of good agricultural practices, value addition and marketing for the value chain. Relevance of the content is based on needs identified among value chain players, actors and aligned to GEAP project objectives.

MESPT is grateful to the value chain experts who spearheaded the development and production of this manual. It is my hope that counties and other users will adopt and optimally use this resource so as to increase productivity and profitability while ensuring a greener and more inclusive growth.

Doreen Kinoti

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Acknowledgements

The Green Employment in Agriculture Programme (GEAP) participating counties (Kilifi, Kwale, Nakuru, Nyandarua, Siaya, Kisii, Kakamega, Bungoma, Trans Nzoia, Uasin Gishu, Makueni and Machakos) are acknowledged for providing resource persons in compilation of the document. The technical support and expertise provided by Kenya Agricultural and Livestock Research Organisation in development of the document is appreciated. Thanks to the Royal Danish Government's Danish International Development Agency (DANIDA) for facilitating the development of this re-source material. Micro Enterprises Support Programme Trust (MESPT) is appreciated for co-ordinating the process of development and production of this document.

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CHAPTER 1: INTRODUCTION

1.1 Banana (Musa spp.) Production: An Overview

Bananas are believed to have originated up to 10,000 years ago, with their primary sites of origin thought to be the Malaysian Peninsula, the Philippines, and New Guinea. Today, bananas are one of the most important fruit crops globally.

Bananas are an important crop in Kenya, accounting for 35% of the total fruit market volume, representing 11% of the value of all horticultural crops in the country. Bananas also serve as a source of livestock feed in some areas.

Key banana varieties in Kenya include:

Ripening types: Gros Michel, Apple, and Grand Nain

Cooking types: Ng'ombe and Uganda Green

Multipurpose varieties: *Muraru* and FHIA varieties

Banana cultivation is widespread, with over **2 million households** engaged in production (KNBS, 2019). The total area under banana cultivation is approximately **168,000 acres** (AFA, 2022).

Kenya's annual banana production exceeds **1.9 million tons**, with a market value of **26 billion Kenyan Shillings** (AFA, 2022). National per capita banana consumption is estimated at **34.3 kg per year** (FAOSTAT, 2021).

1.2 Global Banana Production

The leading global producers of bananas are:

India: 31.5 million tons

China: 12 million tons

Indonesia: 7.3 million tons

Brazil: 6.8 million tons

Ecuador: 6.6 million tons

According to the FAO (2022) report, in Africa, **Angola** is the top producer with 4.4 million tons annually, followed by:

Rwanda: 3.5 million tons

Tanzania: 2.1 million tons

Kenya: 1.9 million tons

Egypt: 1.2 million tons (FAO, 2021)

1.3 Bananas in Africa

In many African countries, bananas serve as a staple food and a key income earner through trade. The crop is grown in a variety of forms: some bananas are used for cooking, while others are grown for dessert consumption. These varieties provide vital nutrition and economic support for millions of people across the continent.

Banana production in Africa has increased over the years, thanks to favorable soils and climate in many regions. However, several challenges have slowed its growth, including:

Diseases such as Black Xanthomonas Wilt (BXW) and Sigatoka

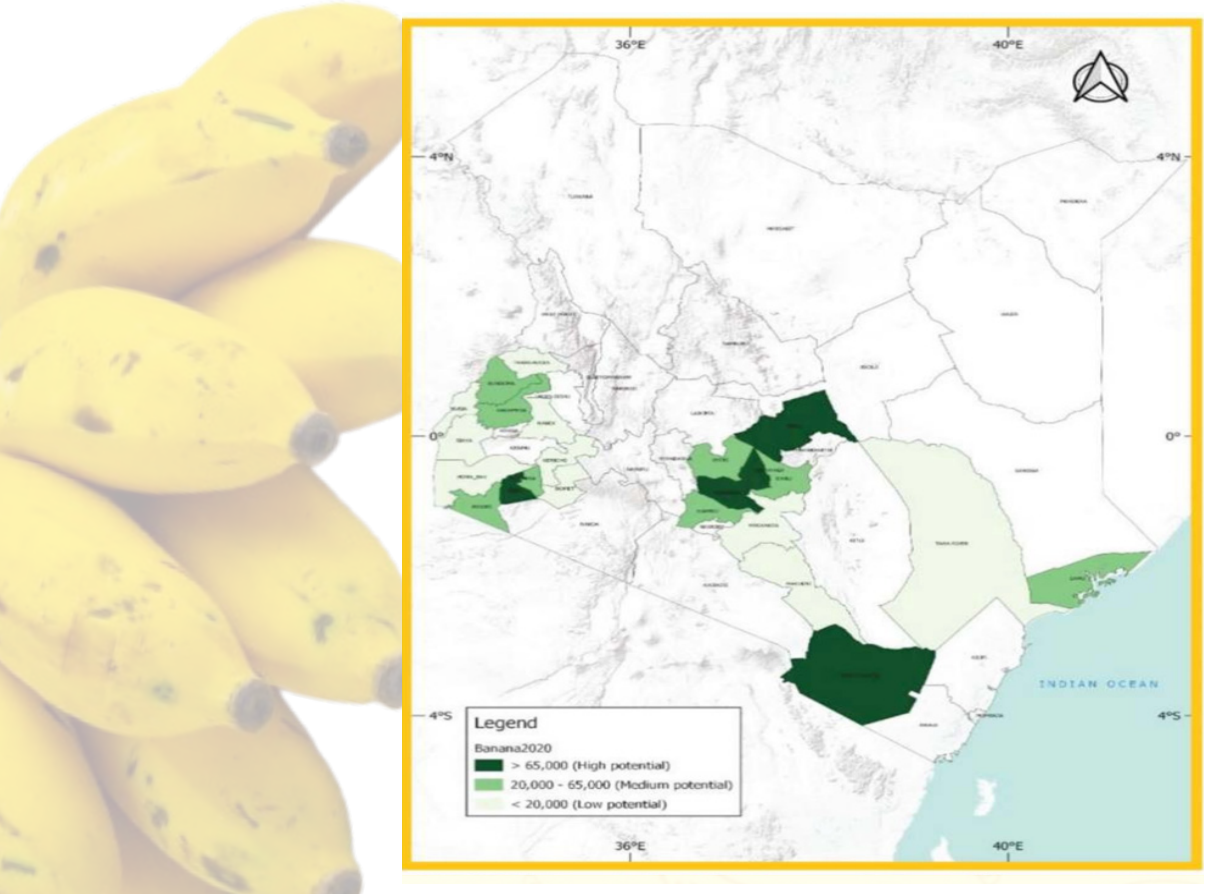
Weather fluctuations

Market access issues

1.4 Banana Production in Kenya

A significant number of banana farmers in Kenya are resource-poor and face various challenges. These include limited access to clean planting material, the use of low-yielding banana varieties, declining soil fertility, high incidences of pests and diseases, substantial post-harvest losses, and limited adoption of modern technologies, innovations, and management practices. Additionally, the impacts of climate change have led to increased weather variability, while farmers also struggle with inadequate control over market prices.

On average, farmers sell up to **86%** of their banana harvest (USAID, 2015). A large proportion of banana produce is consumed locally, with major towns and cities being the primary buyers. The cities of **Nairobi** and **Mombasa** have the highest demand and consumption of bananas in the country (USAID, 2015).



Below is a summary of banana production in different areas of Kenya.

COUNTY	2019			2020			2021			% of Total Value
	Area (Ha)	Volume (MT)	Value (KES)	**Area (Ha)**	Volume (MT)	Value (KES)	**Area (Ha)**	Volume (MT)	Value (KES)	
Meru	13,031	371,391	5,719,418,697	14,012	484,936	6,843,372,560	14,209	776,678	8,719,668,520	32.3
Murang'a	6,366	156,133	2,420,063,360	7,338	161,859	2,303,439,288	8,626	253,476	3,240,613,773	12
Kirinyaga	3,547	99,316	1,489,740,000	4,312	185,133	2,282,732,000	3,859	149,377	1,858,080,000	6.9
Taita Taveta	5,405	142,692	2,211,726,000	4,909	238,750	2,804,625,000	3,195	88,758	1,415,235,000	5.2
Kisii	8,342	178,132	2,133,761,493	6,019	119,662	1,565,162,500	5,332	111,767	1,206,005,400	4.5
Nyamira	3,332	44,990	858,020,000	3,316	43,550	877,821,132	2,842	40,450	816,724,528	3
Bungoma	3,321	38,188	498,538,276	2,401	64,450	1,009,791,800	2,235	42,132	775,466,000	2.9
Tharaka	3,419	72,074	1,048,208,000	4,283	54,980	682,495,500	1,564	56,443	755,859,150	2.8
Kiambu	2,451	64,873	720,788,360	2,140	60,921	1,197,137,500	2,189	79,490	729,545,000	2.7
Kakamega	2,366	17,574	439,559,000	2,518	38,380	742,000,000	2,745	34,587	576,311,948	2.1
Homabay	1,377	19,866	434,371,000	1,254	16,700	463,549,240	1,422	19,136	544,264,160	2
Siaya	1,312	10,154	455,850,000	1,446	15,106	463,935,000	1,873	21,006	538,576,360	2
Lamu	3,237	61,356	1,285,800,000	2,001	63,924	1,549,680,000	1,845	19,000	496,000,000	1.8
Migori	813	27,278	421,612,456	1,613	44,246	614,080,380	1,614	32,280	478,876,750	1.8
Kericho	412	12,023	421,256,000	466	12,872	504,960,000	530	14,321	447,990,000	1.7
Nyeri	1,670	37,967	464,461,856	1,352	37,459	399,277,376	1,333	32,556	410,773,780	1.5
Embu	1,583	37,992	531,888,000	1,304	44,870	610,700,000	1,121	36,580	386,460,000	1.4
Makueni	667	6,112	328,500,035	539	10,631	323,682,786	504	11,005	377,870,000	1.4
Others	9,250	113,902	2,739,318,831	11,264	173,093	3,790,449,143	10,994	165,240	3,186,095,026	11.8
Total	71,901	1,512,013	24,622,881,364	72,486	1,871,521	29,028,891,206	68,032	1,984,282		100

CHAPTER 2: PLANTING MATERIAL AND PROPAGATION

2.1 Sources of Planting Material for Banana Propagation

The success of a banana crop largely depends on the quality of the planting material used. There are several sources of planting material for banana propagation, each with its advantages and challenges. The most common sources include **tissue culture plantlets**, **macropropagation**, and the use of **suckers**, specifically **sword suckers** and other more mature suckers. Each source has its role in banana farming, depending on the farmer's resources, the intended scale of production, and the desired crop quality.

2.2 Tissue Culture Plantlets

Tissue culture technology is a modern method of banana propagation that produces **disease-free** plantlets in a controlled, sterile environment. This method involves growing small pieces of the banana plant (such as meristematic tissue) in a nutrient-rich medium under highly controlled conditions. The resulting plantlets are genetically identical to the parent plant and are free from the pests and diseases that may be present in conventional propagation methods.

2.2.1 Advantages of Tissue Culture Plantlets:

Disease-Free: The primary advantage of tissue culture is the production of disease-free plantlets, ensuring that pests and diseases do not carry over to the new plants. This is particularly important in regions with high disease pressure, as it helps improve the overall health and productivity of the orchard.

High Quality and Uniformity: Tissue culture plantlets tend to have higher uniformity in terms of growth and development, leading to more consistent yields.

Better Root System: The plantlets generally develop a strong root system, which helps with better anchorage and nutrient absorption.

2.2.2 Challenges of Tissue Culture Plantlets:

Cost: Tissue culture plantlets tend to be more expensive than other types of planting material, which may be a limitation for smallholder farmers.

Availability: Depending on the region, tissue culture plantlets may not always be readily available, making access a challenge in some areas.

Tissue culture plantlets are usually produced in specialized laboratories and are best suited for large-scale commercial banana farming, where uniformity and disease control are paramount.

2.3 Macropropagation

Macropropagation is another common method of banana propagation that involves the use of larger suckers or parts of the banana plant (such as rhizomes or corms) for planting. This method is cheaper than tissue culture and can be a good alternative for smallholder farmers.

2.3.1. Advantages of Macropropagation:

Lower Cost: Unlike tissue culture, macropropagation does not require sophisticated laboratory facilities, making it more affordable for many farmers.

Faster Availability: Suckers and rhizomes are often available locally, making them more accessible compared to tissue culture plantlets.

2.3.2 Challenges of Macropropagation:

Potential for Disease Transmission: Since macropropagation relies on vegetative material from existing banana plants, there is a risk of passing on diseases and pests. However, this can be mitigated by ensuring that only healthy, disease-free parent plants are used for propagation.

Inconsistent Quality: The quality of plant material can vary depending on the source, which may result in plants with varying growth rates and yields.

2.4 Use of Sword Suckers

Sword suckers are young, vigorous suckers that are usually the most suitable for planting. They are typically the second or third suckers that emerge from the banana plant after the mother plant begins to bear fruit. Sword suckers have a strong genetic potential for producing high yields, and they generally produce healthier plants with better resistance to diseases compared to older suckers.

2.4.1 Advantages of Sword Suckers:

Vigor: Sword suckers tend to be strong and vigorous, leading to faster establishment and higher productivity.

Disease Resistance: Since they are younger, sword suckers are less likely to harbor diseases compared to older suckers.

2.4.2 Challenges of Sword Suckers:

Availability: Sword suckers may not always be available, especially in regions where banana plants are not well-managed or where desuckering practices are not followed.

More Time-Consuming: It may take longer to select sword suckers and prepare them for planting compared to using other types of suckers or tissue culture plantlets.

2.5 Use of Mature Suckers

Mature suckers are the older, well-established suckers that emerge from the base of the banana plant. These suckers can be used for propagation, although they are generally not as ideal as sword suckers or tissue culture plantlets.

2.5.1 Advantages of Mature Suckers:

Readily Available: Mature suckers are often easy to find and can be obtained from the same banana farm where they are growing, making them convenient and cost-effective for farmers with limited resources.

Resilient: Older suckers may be more resilient to adverse environmental conditions, as they are already somewhat established.

2.5.2 Challenges of Mature Suckers:

Risk of Disease: Mature suckers are more likely to carry diseases and pests, especially if the parent plant was infected. This can lead to the spread of diseases in the new plantation.

Slow Establishment: Mature suckers may take longer to establish compared to sword suckers or tissue culture plantlets, as they often have less vigor and a more extensive root system.

2.6 Selecting the Right Planting Material

When choosing planting material, farmers must consider several factors, including the cost, availability, and the risk of diseases. While **tissue culture plantlets** offer the highest quality and disease resistance, they may be less affordable for small-scale farmers. **Macropropagation** and the use of **suckers** (especially sword suckers) offer more accessible and cost-effective alternatives, but they come with the potential risk of disease transmission.

Regardless of the propagation method used, it is essential to ensure that the planting material is healthy and free from diseases, as this significantly impacts the long-term productivity and profitability of the banana farm. For optimal results, farmers should also implement good farm management practices such as proper field sanitation, regular desuckering, and crop rotation to reduce the risk of pest and disease outbreaks.

By sourcing planting material from trusted and registered nurseries, farmers can significantly improve the quality of their banana crops while minimizing risks associated with poor-quality planting material.

2.6.1 Risk of Disease Spread

Using infected sword suckers from unregulated sources can introduce harmful pathogens into the orchard, leading to poor plant health and reduced yields.

2.6.2 Mitigation Measures

To reduce the risk of disease transmission, it is essential to **disinfect** sword suckers before planting. A common method is the use of **hot water treatment**, which helps eliminate pests and pathogens present on the suckers' surface. This practice improves the health of the plants and contributes to better long-term productivity.

By following proper sanitation practices and disinfecting sword suckers, farmers can help break the cycle of disease transmission, leading to healthier banana crops and more sustainable farming practices.

In the absence of **Tissue Culture** banana seedlings, **sword suckers** can serve as an effective propagation material. Sword suckers are the young shoots that emerge from the base of the banana plant. These suckers are characterized by:

Appearance: Narrow leaves and a height of about **1 meter** with a diameter of approximately **15 cm** at the base.

Source: Sword suckers are typically sourced from existing banana orchards, and care must be taken to ensure they are healthy and free from pests and diseases. Since sword suckers are taken from mature plants, they may carry pests such as **nematodes** and **banana weevils**, which can spread diseases to new orchards. To prevent this, it is essential to disinfect the suckers before planting. This can be done by following the procedure below:

2.6.3 Summary of steps for Treating Sword Suckers:

Trim the roots of the sword sucker to remove any damaged or diseased tissue.

Cut off 1 cm of tissue around the corm, continuing until clean, white tissue is exposed.

Prepare the hot water bath: Heat water to a temperature between **50°C – 55°C**.

Immerse the corm in the hot water bath for **20 minutes** to kill any pests or pathogens.

2.6.4 Alternative Method

In cases where a thermometer is unavailable on the farm, **boiling water** can be used as an alternative. Simply dip the sucker in the boiling water for **30 seconds**. This will help eliminate pests, though care must be taken not to overheat or damage the sucker.

By following these steps, farmers can reduce the risk of introducing pests and diseases into the orchard, leading to healthier, more productive banana crops.

2.7 Land Preparation and Planting Practices

Proper land preparation is essential for successful banana planting, as it ensures that the plants have an ideal environment for growth. Follow these recommended practices for effective planting and soil management:

Deep Soil Cultivation: Prior to planting, conduct deep soil cultivation by ploughing and harrowing the field. This helps to break up compacted soil, improve aeration, and promote root development.

Clear the Field: Ensure that the field is free of trees, bushes, and, most importantly, **perennial weeds**. These can compete with banana plants for nutrients, water, and light, negatively affecting plant growth.

Planting Hole Size:

For most areas, it is recommended to dig a **60 cm x 60 cm x 60 cm** planting hole. However, this can be adjusted depending on local conditions, particularly water availability.

In **dry and semi-arid areas**, it is advisable to use **larger holes** of **90 cm x 90 cm x 90 cm** to allow for better root establishment and water retention.

Soil Drainage: Bananas are highly sensitive to **stagnant water** and cannot tolerate waterlogging. Ensure the soil has **good drainage** to prevent root rot and other water-related issues.

Recommended Planting Spacing: Proper spacing is crucial for healthy growth and optimal yields. The recommended spacing for different banana varieties is:

Short Varieties: **3 m x 3 m** (444 plants per acre)

Medium Varieties: **3 m x 4 m** (333 plants per acre)

Tall Varieties: **4 m x 4 m** (250 plants per acre)

2.8 Fertilizer Application and Hole Preparation

To provide the plants with the necessary nutrients for strong growth, follow these fertilizer application and hole preparation steps:

Soil Mixing: Separate the topsoil and subsoil before filling the planting hole.

Mix the topsoil with **2–3 "debes" (20-30 kg)** of well-decomposed manure.

Add **200 g of Triple Super Phosphate (TSP)** to the mixture to improve root development and overall plant health.

Filling the Hole:

First, refill the planting hole with the prepared topsoil mixture, followed by the subsoil.

Ensure the hole is filled evenly and leveled.

Settling Time: Allow the filled holes to settle for at least **2 weeks** before transplanting. This ensures that the soil is properly compacted and ready for planting.

By following these practices, you will create a conducive environment for banana plant establishment, leading to healthy growth, reduced pest and disease risks, and increased productivity.

Banana plantlets produced through Tissue Culture

Sword Suckers (Source: Shep Plus 2022

Plantlets in hardening nursery Source: ShepPlus 2018)

Hardened plantlets ready for planting

Bananas are a vital staple crop in many parts of Kenya, grown not only for local consumption but also as a significant cash crop. In Kenya, bananas are cultivated across diverse agro-ecological zones, from the fertile highlands to the lower, more arid regions, and they play a crucial role in the livelihoods of millions of smallholder farmers. The crop's popularity can be attributed to its versatility, as different banana varieties cater to a wide range of consumer preferences and culinary uses.

2.9 Banana Varieties

Banana production in Kenya involves the cultivation of several distinct varieties, each suited to particular growing conditions and uses. These varieties can broadly be classified into three categories: **dessert (ripening) bananas**, **cooking bananas**, and **multipurpose cultivars**.

2.9.1 Dessert Bananas (Ripening Cultivars):

These are primarily grown for fresh consumption, either as a snack or as part of various dishes. The most common dessert banana varieties in Kenya include:

Gros Michel

Apple

Giant Cavendish

Paz

Dwarf Cavendish

Williams Hybrid

Grand Nain

Valery

Lacatan

Uganda Red

These bananas are known for their sweet flavor, smooth texture, and ability to ripen evenly, making them popular both locally and for export.

2.9.3 Cooking Bananas:

These varieties are grown primarily for their starchy content and are cooked in various ways before consumption. The most notable cooking banana varieties in Kenya include:

Ng'ombe

Uganda Green

Plantains

Cooking bananas are often used to prepare traditional dishes such as *Matoke* (steamed banana) or *Kachumbari* (fried banana), and are an important part of the diet in many parts of Kenya.

2.9.4 Multipurpose Cultivars:

These bananas are valued for their versatility, being suitable for both cooking and ripening. The key multipurpose varieties include:

Muraru

FHIA Varieties (FHIA 01, FHIA 23, FHIA 17)

These cultivars are particularly appreciated for their ability to withstand various environmental conditions, making them well-suited for smallholder farming systems.

The success of banana production relies heavily on the selection of high-quality planting material. The choice of variety influences not only the yield and quality of the bananas but also the resilience of the crop to pests, diseases, and environmental stressors. In this chapter, we will discuss the different types of planting material, including tissue culture plantlets, clean suckers, and macro-propagation techniques, and provide guidance on how to propagate banana plants for optimal growth and productivity.

2.10 Descriptions of common banana varieties

Giant Cavendish (Source Shep Plus 2018).

Banana cultivation in Kenya includes a range of varieties, each with unique characteristics that make them suitable for different purposes and growing conditions. The following are some of the most common banana varieties grown in Kenya:

2.10.1 "Chinese Dwarf"

Height: A shorter variety compared to others like the Cavendish group.

Propping Requirement: Does not require propping due to its smaller stature, making it easier to manage in terms of mechanical support.

Growing Conditions: Well-suited for cultivation at higher altitudes (up to 2,100 m above sea level), making it ideal for cooler regions of Kenya.

Disease Resistance: Resistant to Fusarium wilt (Panama Disease), providing protection against this destructive soil pathogen.

Disease Susceptibility: Susceptible to *Cigar-end Rot* (a condition that causes fruit spoilage) and Black Sigatoka, a leaf disease that can impact photosynthesis and yield.

Use: Primarily a dessert banana, it is also known for its sweet flavor and compact size.

2.10.2 "Giant Cavendish"

Type: A cultivar of the Cavendish group.

Environmental Tolerance: Tolerant to various environmental stresses, making it a robust choice for farmers.

Fruit Quality: Produces high-quality bunches with uniformly yellow fruits.

Shelf Life: Mature fruits have a good shelf life, making them suitable for both local and export markets.

Propping Requirement: Requires propping to prevent stem breakage due to the heavy bunch.

2.10.3 "Williams Hybrid"

Bunch Size: Known for producing large bunches.

Fruit Quality: The fruits are highly regarded for their excellent flavor, aroma, and taste when ripe.

Shelf Life: Ripe fruits have a relativel

2.10.4 "Valery"

Height: A tall variety with a strong pseudo-stem, making it stable and robust.

Taste: Known for good taste, which makes it popular for both local consumption and markets.

Propping: Like many other tall varieties, it requires propping for support.

2.10.5 FHIA Hybrids:

FHIA-17, FHIA-18, FHIA-23, FHIA-25

Development: These hybrids were developed by the International Institute of Tropical Agriculture (IITA) for improved disease resistance and yield.

Disease Resistance: Resistant to *Black Sigatoka*, a major banana leaf disease, ensuring better plant health and productivity.

Uses: Suitable for both cooking and dessert purposes.

Bunch Size: Produces heavy bunches, averaging 50 kg per bunch.

Propping Requirement: The plants require support to prevent lodging due to their large bunches and tall stature.

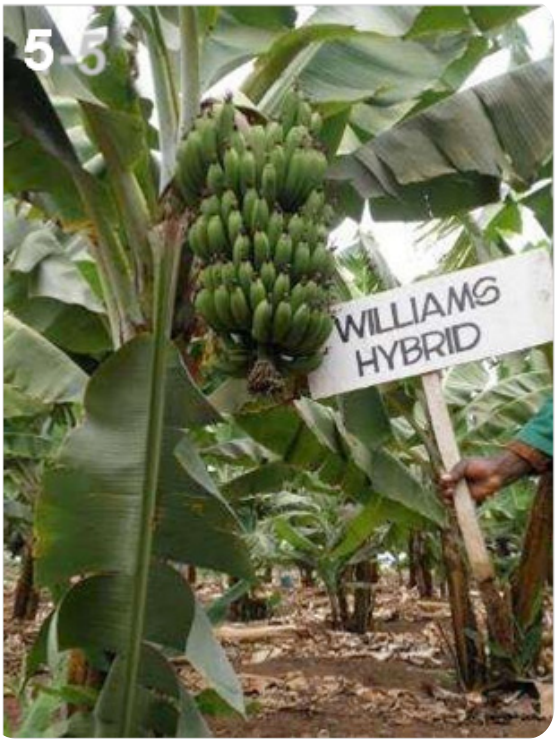
2.10.6 Other Notable Varieties

In addition to the above, there are several other banana varieties grown in Kenya, each with unique characteristics and uses. These include:

Ng'ombe, Lacatan, Apple (Sweet), Gros Michel, Poyo, Kisii Matoke, *Muraru*, sweet/Sukari, Bogoya, Kampala, Kisigame, Manyoke, Kiganda, and Mutah.

These varieties offer a diverse selection for banana farmers, with options for dessert bananas, cooking bananas, and multipurpose cultivars. Understanding the characteristics of each variety helps farmers select the best one for their specific needs, improving both yield and marketability.

These varieties, while differing in characteristics such as height, disease resistance, and the need for mechanical support, represent just a fraction of the banana cultivars grown in Kenya. Farmers select the variety that best suits their local conditions, such as altitude, climate, and disease pressures, as well as their intended use for the crop (dessert, cooking, or multipurpose). Understanding the characteristics of these varieties is crucial in making informed decisions about banana production, as it directly impacts yield, quality, and overall farm profitability.



CHAPTER 3: CROP MANAGEMENT

Effective management of banana orchards is key to ensuring healthy plant growth, high yields, and long-term sustainability. Key practices include desuckering, which removes excess suckers to maintain optimal plant growth; manure and fertilizer application to provide essential nutrients and maintain soil fertility; and propping to support the banana plants and prevent stem breakages that can lead to significant losses.

Pruning of old and damaged leaves is essential to improve light penetration, enhance air circulation, and reduce disease buildup within the canopy. Judicious water management is also crucial, especially in areas with fluctuating rainfall, to prevent both waterlogging and drought stress. By carefully managing water, farmers can ensure that bananas receive the optimal moisture needed for healthy growth.

Together, these practices form the foundation for a healthy, productive banana orchard, ensuring that the plants thrive throughout their lifecycle while minimizing losses and improving overall yield and quality.

3.1 Banana Agronomic Practices

3.1.1 Overview

Successful banana production requires a combination of good agronomic practices to ensure high yields and sustainable production. Key practices include selecting disease-free planting materials and choosing sites that are free from disease and previous crop debris to reduce the risk of contamination and promote healthy growth. Proper site preparation, including effective soil management to maintain fertility, is also essential. Farmers are encouraged to adopt crop rotation, intercropping, and the use of organic and chemical fertilizers to enhance soil health. Pest and disease management, including control of common threats like the common pests and diseases is crucial for maintaining healthy plants and reducing losses. Additionally, proper irrigation, pruning, and mulching techniques are vital to optimize growth and protect bananas from extreme weather conditions. By incorporating modern farming techniques alongside traditional practices, banana farmers in Kenya can increase productivity and improve the resilience of their crops.

3.2 Site selection.

Site selection is a critical factor in successful banana production. Farmers should choose locations that are free from disease and previous crop debris, with well-drained, fertile soils and favorable climatic conditions to promote optimal growth. A soil analysis is recommended before establishing the crop to ensure the land has the necessary nutrients and pH levels. For sloping land, erosion prevention measures, such as contour planting or terracing, should be implemented to protect the soil. In areas prone to strong winds, erecting windbreaks can help shield banana plants and prevent damage. Additionally, it is beneficial to locate the farm near essential amenities, such as roads, water sources, and markets, to facilitate easy access to resources and improve the overall efficiency of production and distribution.

3.3 Soil analysis

Soil analysis is a critical practice for effective nutrient management in banana production. By collecting soil samples and analyzing them for nutrient content, farmers can identify deficiencies, imbalances, or excesses in the soil, enabling them to make informed decisions on fertilization and soil amendments. This helps optimize nutrient use, minimize unnecessary input costs, and maximize crop yields. When collecting soil samples, it is essential to avoid sampling from walking paths or areas with unnatural

soil disturbance, as this could skew the results. For accurate and reliable results, soil analysis should be conducted at reputable laboratories that adhere to standard testing procedures. Regular soil testing is an important tool in maintaining soil health and ensuring sustainable, high-yielding banana production.

3.4 Site preparation

For optimal banana production, proper site preparation is essential. Before planting, deep soil cultivation through ploughing and harrowing is recommended to ensure good soil aeration and structure. The field should be cleared of trees, bushes, and especially perennial weeds to reduce competition for nutrients and water. A planting hole measuring 60 cm x 60 cm x 60 cm is generally recommended, although the size may vary depending on water availability and soil conditions. In areas with sufficient water, high soil fertility, and good disease control, closer planting spacings such as 2m x 2m have been successfully used, particularly for short to medium banana varieties. In dry and semi-arid regions, larger planting holes of 90 cm x 90 cm x 90 cm are recommended to ensure that plants have enough space for root development and access to water. These practices, when combined with appropriate irrigation, fertilization, and disease management, contribute to healthy, high-yielding banana crops.

3.5 Crop Establishment

Transplanting banana plantlets is a crucial step for successful crop establishment and growth. For optimal results, tissue culture plantlets should be at least 30 cm tall and have a minimum of 5 healthy leaves before transplanting. This ensures the plantlets are strong enough to thrive in the field.

When transplanting, the plantlet should be placed 30 cm deep into the planting hole to provide stable anchorage and encourage strong root development. The hole should be large enough to accommodate the roots without overcrowding. Care must be taken to gently spread the roots to avoid damage that could hinder growth.

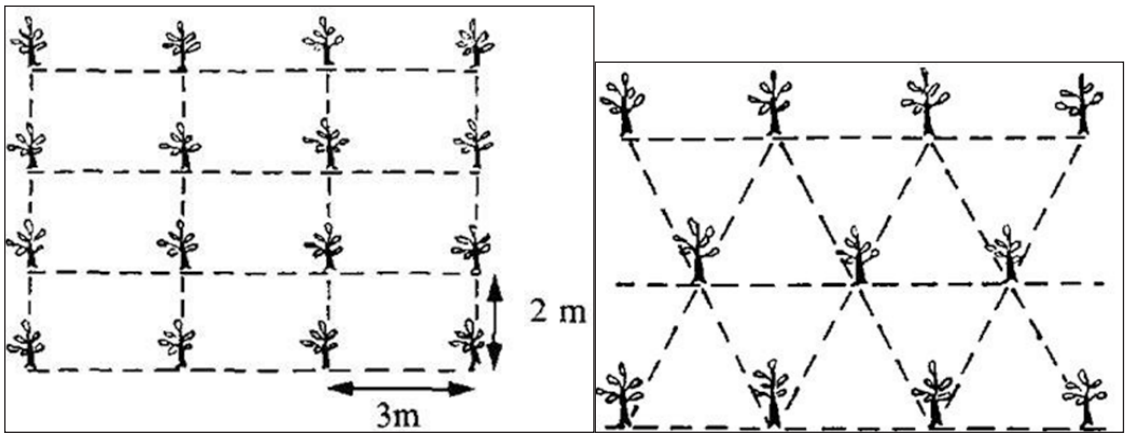
After transplanting, applying mulch around each plant is highly beneficial. Mulch helps conserve soil moisture, suppress weeds, and regulate soil temperature, all of which are crucial for healthy growth, particularly during dry spells. It also helps protect the roots from temperature extremes and moisture stress.

Under rainfed conditions, planting should be done at the onset of the rains to ensure the plantlets receive enough moisture for proper establishment. In areas with irrigation, planting can be done throughout the year, ensuring consistent moisture for optimal growth.

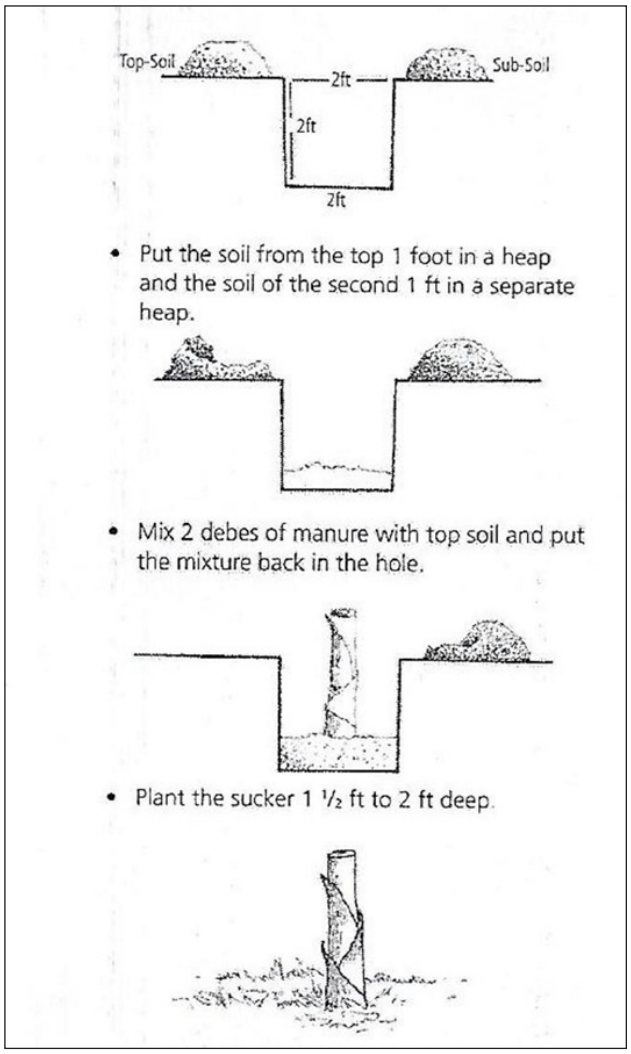
Proper field preparation is essential before transplanting. The soil should be free of weeds and debris that could compete with the plantlets for nutrients and water. Adequate spacing between plants is also important to ensure proper air circulation, light penetration, and room for growth—all critical factors for healthy banana development.

By following these best practices, farmers can ensure that banana plantlets establish well and are positioned for strong growth and high yields

3.6 Planting patterns



Source: Banana Handbook (KALRO, 2022)



Source: KALRO, 2022

3.7 Ecological Requirements for Banana Production

Bananas thrive under specific ecological and climatic conditions that support healthy growth, optimal yield, and high-quality fruit production. Understanding these requirements is essential for maximizing performance, profitability, food safety, and environmental sustainability in banana farming. By aligning banana cultivation with these optimal conditions, farmers can enhance both the economic viability and environmental sustainability of their operations.

3.7.1. Altitude

Definition: Bananas grow best in hot and humid conditions, typically found at altitudes between **0 and 1,800 meters** above sea level.

Importance: Altitude directly influences temperature and humidity levels, which are critical for banana development. In regions with the right altitude range, bananas benefit from the consistent warmth and humidity needed for healthy growth. Altitudes higher than 1,800 meters may result in cooler temperatures, which can slow down growth and reduce yields.

Impact: Growing bananas at the right altitude ensures optimal fruit development and improves **yield potential**. This not only boosts farm profitability but also enhances fruit quality, meeting market demands for bananas with consistent size and taste.

3.7.2. Rainfall

Definition: Bananas require **1,000 to 2,000 mm of rainfall annually**, with **200 to 220 mm per month**, well-distributed throughout the year.

Importance: Adequate rainfall supports steady growth and fruit maturation. Consistent moisture ensures that the plants have the water needed for nutrient uptake and healthy development. Too little rainfall can stress the plants, leading to poor growth, smaller fruits, and lower yields. Conversely, excessive rainfall can lead to waterlogging and root diseases.

Impact: Proper rainfall is crucial for **yield consistency** and **quality**. In areas with insufficient rainfall, **irrigation** may be required to ensure proper water supply, especially during dry spells. Adequate water management improves **farm profitability** by reducing crop loss and increasing productivity. Additionally, it contributes to **food safety** by reducing stress on the plants, which can make them more susceptible to pests and diseases.

3.7.3. Temperature

Definition: Bananas grow best in temperatures around **27°C**, which is considered the optimal range for photosynthesis and overall plant development.

Importance: Temperature affects metabolic processes in banana plants, influencing growth rates and fruit development. Temperatures too high (above 35°C) can cause heat stress, reducing fruit size and quality, while temperatures below 14°C can stunt growth and delay fruiting.

Impact: Maintaining the right temperature range ensures healthy, fast growth, leading to higher yields and improved fruit quality. This is critical for achieving profitable banana production that meets market demand for fresh, high-quality fruit. Consistent temperatures also help with food safety by reducing the likelihood of diseases caused by temperature fluctuations.

3.7.4. Soil Type

Definition: Bananas require deep, friable loam soils that are rich in organic matter, with a pH range of 6.0 to 7.5.

Importance: Soil quality directly impacts the banana plant's ability to absorb nutrients and water. Deep soils allow for healthy root growth, while well-draining loam soils prevent waterlogging, which can cause root rot. Soils with the right pH (slightly acidic to neutral) provide optimal conditions for nutrient availability.

Impact: Good soil quality supports strong plant growth and high yields. Bananas grown in fertile soils are more resilient to stress, pests, and diseases, reducing the need for chemical inputs. This contributes to environmental sustainability by promoting soil health and reducing reliance on fertilizers. Proper soil management also enhances food safety, as healthier plants are less likely to carry harmful contaminants or pests.

3.7.5. Wind Protection

Definition: Bananas are highly sensitive to strong winds, which can cause leaf tearing and lodging of plants (falling over). To mitigate this risk, windbreaks should be established around the orchard.

Importance: Windbreaks reduce wind speed and protect banana plants from damage. Strong winds can result in broken stems, torn leaves, and increased vulnerability to diseases, particularly fungal infections. Windbreaks help maintain the structural integrity of the plants and reduce the risk of crop loss.

Impact: Wind protection improves the structural stability of banana plants, leading to reduced crop damage and higher yields. This directly supports economic profitability, as fewer plants are lost to wind damage. Additionally, reducing wind damage minimizes post-harvest losses and improves fruit quality, ensuring better marketability.

3.8 Desuckering in Banana Production

Desuckering is a vital practice in banana production that involves the removal of unwanted suckers to support the healthy growth and development of the plant. While banana plants naturally produce multiple suckers, not all of them are necessary for optimal production. The goal of desuckering is to retain the healthiest and most productive suckers while eliminating excess ones that can lead to overcrowding, reduced nutrient availability, and poor yields.

A well-managed banana plant typically maintains three types of suckers:

Mother plant: The primary, fruit-bearing plant.

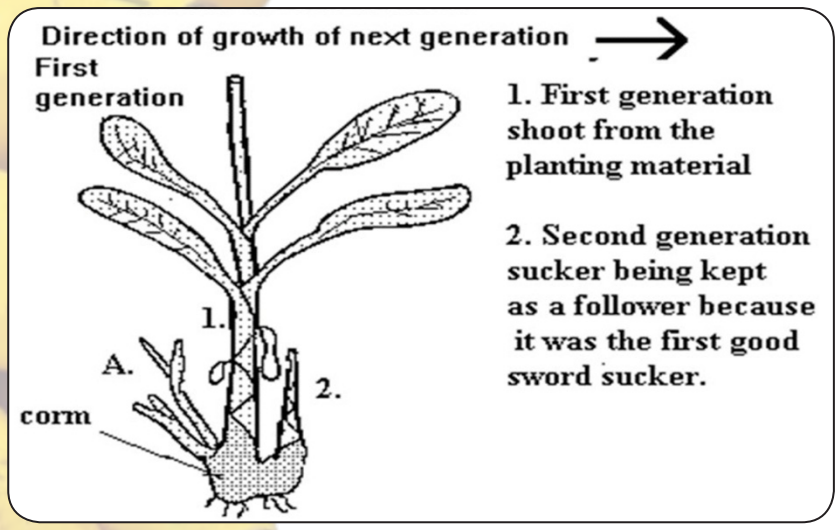
Daughter plant: A half-grown sucker that will replace the mother plant after harvest, ensuring continuous production.

Granddaughter plant: A younger, sprouting sucker that will eventually become the daughter plant in future cycles.

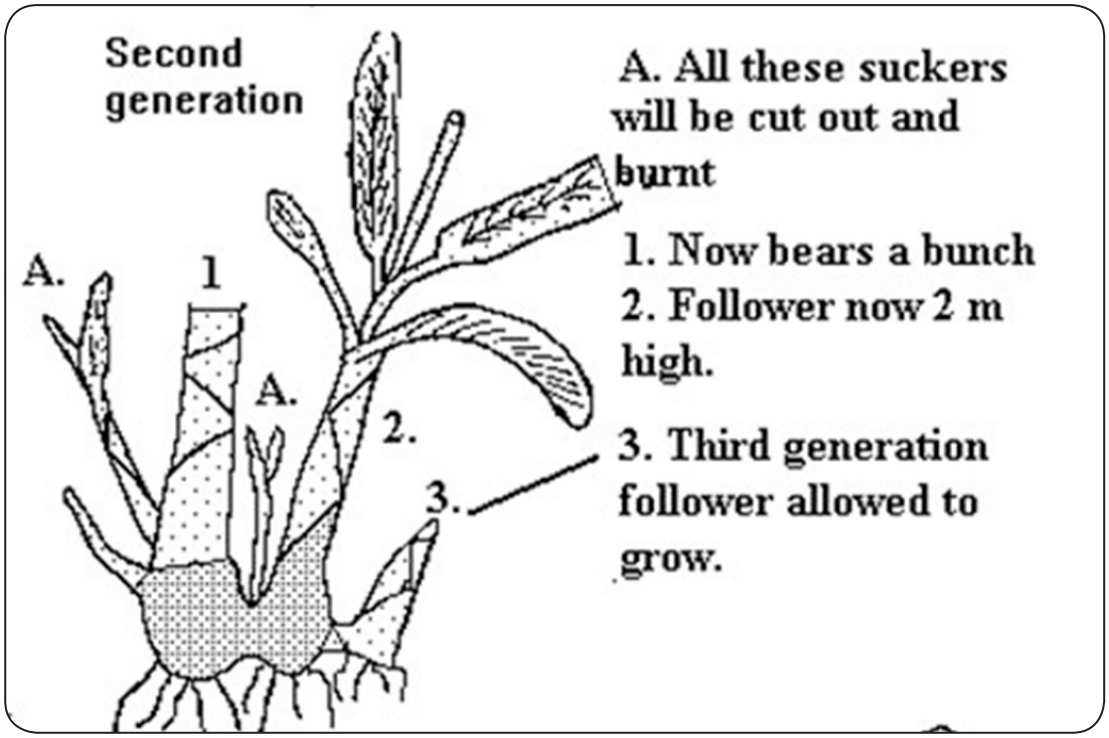
In high rainfall areas, up to five suckers may be maintained to optimize production. However, only the healthiest suckers should be kept, while the rest are removed to reduce overcrowding and ensure the plants receive adequate nutrients, space, and sunlight.

Desuckering should be done carefully using a desuckering tool to dig out unwanted suckers. It is important to remove the suckers at their base to prevent re-growth. This process should be repeated every **45 days** to ensure that only the desired suckers are retained. Regular desuckering helps maintain proper air circulation and light penetration, which are essential for optimal growth.

In addition to promoting plant health, desuckering reduces the risk of pest and disease outbreaks, as overcrowded plants are more susceptible to infections. Proper desuckering is therefore key to maintaining a balanced, productive banana orchard, ensuring continuous production and minimizing disruptions in the plant cycle.



Source: KALRO 2022



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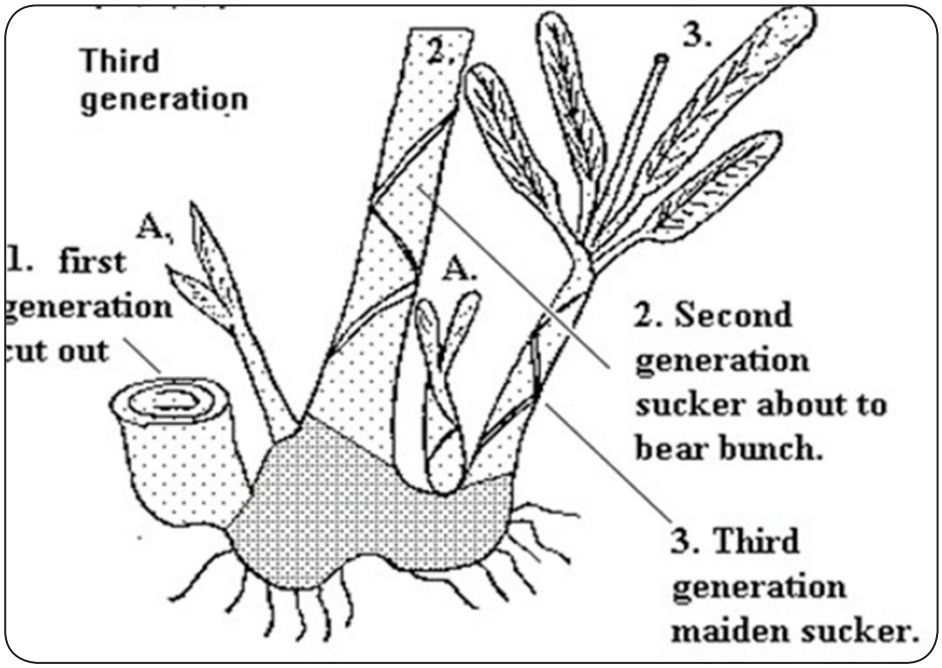


Source: KALRO 2022

3.9 Field sanitation

Field sanitation is an essential practice in banana production aimed at maintaining a clean and healthy growing environment. This involves regularly removing plant debris, dead leaves, and decaying banana material, as these can attract pests and promote disease. Effective cultural control strategies, such as the removal of plant debris and the shredding or burning of side coppices, help eliminate weevils and other pests that may infest the field. Proper sanitation reduces the risk of pest infestations and disease outbreaks, leading to improved plant health, better growth, and higher yields. Additionally, sanitizing tools and equipment helps prevent the spread of contaminants, supporting the overall productivity and sustainability of the banana orchard.

Propping

Propping is an important practice in banana production that involves supporting banana plants, especially those with mature or immature bunches, to prevent them from lodging or breaking due to the weight of the fruit. This is typically done by placing **a** pole with a V-shaped end beneath the bunch to provide stability and support as the fruit develops. The prop must be carefully positioned to avoid causing injury to the bunch or the plant. Propping helps maintain the upright position of the plant, reducing the risk of damage from wind, heavy rain, or the sheer weight of the fruit, thereby ensuring that the bananas grow to their full potential. This practice is crucial for improving fruit quality, minimizing losses, and increasing overall yield in banana production.

3.10 Pruning

A well pruned banana orchard

Poorly maintained banana orchard

Pruning is an essential practice in banana orchards that helps maintain healthy plants and improve overall productivity. The primary goal of pruning is to remove dry and dead leaves that hang down the sides of the banana pseudostem. These leaves can obstruct light penetration, create favorable conditions for leaf diseases, and increase the risk of damage to the plant during windy periods. Regular pruning ensures that each pseudostem has at least seven healthy leaves at any given time, which is important for optimal photosynthesis and healthy fruit development.

The practice of pruning also helps in improving air circulation within the orchard, reducing the buildup of moisture around the plant, and preventing fungal diseases. After harvesting, the pseudostem should be cut off at ground level and chopped into small pieces. This helps prevent weevil infestations and minimizes the potential for pests and diseases to spread within the field. Overall, proper pruning improves light penetration, reduces the risk of injury, and helps maintain a clean, healthy orchard, contributing to better banana growth and higher yields.

3.11 Removal of male Bud

The removal of the male bud is an important practice in banana production, typically carried out after all the fruits on the bunch have formed. Removing the male bud offers several benefits, including **increased yields**, **faster maturity** of the bunches, and a **reduced risk of thrips** attack. The male bud can harbor pests, and by removing it, farmers can help prevent pest infestations that could otherwise damage the fruit.

It is also essential to disinfect the tools used for cutting the male bud to prevent the transmission or spread of diseases between plants. Proper tool hygiene is critical in maintaining the health of the banana orchard and ensuring that the removal process does not inadvertently introduce new pathogens. By carefully managing this practice, farmers can promote healthier plants, better fruit quality, and higher yields.

Source KALRO 2022

3.12 Application of manure and fertilizers

Supplying the right nutrients is essential for optimal banana growth and productivity. However, excessive application of manure or chemical fertilizers can increase the plant's susceptibility to pests and diseases. To ensure that nutrients are applied in the correct amounts, soil tests provide valuable guidance on the appropriate rates for both manure and fertilizer application. Regular soil testing helps farmers avoid over- or under-fertilization, promoting healthier plants and more sustainable crop management.

3.12.1 How to Prepare Green Manure (15 liters):

Materials Needed:

6 kg of fresh cattle dung

9 liters of water

4 kg of green weed called **Tithonia**

Procedure:

Chop the 4 kg of **Tithonia** into small pieces.

In a bucket, mix the chopped **Tithonia**, cattle dung, and water thoroughly.

Cover the bucket with a piece of cloth or newspaper.

Place the bucket in a shaded area and allow the mixture to ferment for 1 – 2 weeks, depending on the weather conditions.

The green manure is ready when it stops releasing bubbles and the smell ceases.

3.12.2 Application:

Apply 3 liters of the prepared green manure around each banana stool once every three months. This will provide a steady supply of nutrients to promote healthy growth.

3.13 CAN Fertilizer:

Apply 200 g of **Calcium Ammonium Nitrate (CAN)** around each banana stool annually.

Mavuno Banana Fertilizer: Alternatively, apply 250 g of **Mavuno Banana Fertilizer (N:P = 10:3:20 + TE)** every 6 months to meet the plant's nutritional needs.

Fertilizer should be applied in a band around the plant, approximately **60 cm** away from the base of the stool.

3.12.3 Farmyard Manure Application:

Apply 2 – 4 "debes" (about 20-30 kg) of **decomposed farmyard manure** per stem annually, ideally just before the rains.

Apply the manure around the outer edge of the banana plant's canopy, and incorporate it into the soil carefully to avoid damaging the roots

3.13 Water requirement and management

Water management is a critical factor in banana production, as bananas have a high water content, with both the stem and fruit containing significant amounts of moisture. This makes water availability a major determinant of both the plant's growth and fruit quality. For optimal growth, banana plants typically require a minimum of **1,000 mm of rainfall annually**.

In regions with lower rainfall, particularly drier areas, **supplemental irrigation** becomes necessary to ensure that the plants receive consistent moisture throughout the growing season. On average, a banana plant requires **40 to 60 liters of water per week**, which should ideally be applied in **two splits** to maximize water absorption and minimize wastage.

Proper water management helps maintain healthy plants, supports consistent fruit development, and improves overall yield and quality. Ensuring adequate water supply is essential for achieving optimal banana production, especially in areas where rainfall is insufficient or erratic.

Banana orchard under irrigation (Source KALRO 2022)

3.14 Weed Management in Banana Orchards

Weeds should be kept under control in banana orchards, as they compete with the banana plants for essential nutrients, water, and sunlight, hindering their growth and productivity. Effective weed management is crucial for ensuring that bananas receive the nutrients they need to thrive.

Weeds can be managed through several methods, including:

Hoeing: Regularly turning the soil to uproot weeds.

Mulching: Applying organic or plastic mulch around the plants to suppress weed growth and retain soil moisture.

Intercropping: Planting compatible crops between banana plants to naturally reduce weed growth while also benefiting from the additional crops.

Herbicides: Using chemical weed control when necessary, ensuring proper application to avoid damage to banana plants.

By combining these practices, farmers can effectively manage weeds, promote healthy banana growth, and improve overall orchard productivity.

Weed management through mulching (Source KALRO 2022)

3.14 Crop Rotation in Banana Production

Crop rotation is the practice of growing different crops in a field over successive planting seasons. This technique plays a key role in crop protection by helping to break pest and disease cycles, which can otherwise build up when the same crop is grown repeatedly in the same soil. Rotating bananas with other crops can also enhance soil fertility by incorporating a variety of beneficial nutrients, improving the overall health of the soil for future banana crops.

For effective crop rotation, it is important to select crops from different species or genera to maximize the benefits. This approach reduces the risk of soil-borne diseases and pests that target specific crops, while also helping to conserve the environment by promoting biodiversity and reducing the reliance on chemical inputs. Crop rotation, when combined with other sustainable farming practices, can contribute to long-term productivity and resilience in banana production.

3.15 Bunch Covering in Banana Production

Source: KALRO 2022

Bunch covering is the practice of protecting banana bunches by covering them with polyethylene sleeves **or** polybags**.** These sleeves, which are typically transparent and feature small ventilation holes, are designed to shield the developing bunches from environmental stress, pests, and physical damage. The ventilation holes are usually **2%** for cooler seasons and **4%** for hotter seasons, allowing for proper air circulation and temperature regulation.

3.15.1 When to Cover the Bunch:

Bunch covering should be **done** immediately after the last hand of the banana bunch has **opened**. This ensures that the bunch is protected at the crucial stage when the fruit begins to mature.

3.15.2 Benefits of Bunch Covering:

Protection from Mechanical Abrasions: The cover helps prevent physical damage caused by wind, rain, or contact with other objects, which can lead to bruising or scarring on the fruit.

Pest Control: Bunch covering is highly effective in controlling pests, particularly thrips and other insects, which can damage the fruit, reduce quality, and lead to increased disease susceptibility.

Improved Fruit Quality: By protecting the bunch from external damage, covering helps maintain the quality and appearance of the bananas, which is essential for meeting market standards.

Food Safety: Covering the bunch also reduces exposure to contamination from the environment, minimizing the risk of pesticide residue, soil-borne pathogens, and contaminants from pests, thus contributing to food safety.

Economic Importance: By reducing losses due to physical damage and pest infestations, bunch covering helps increase yields, improve marketable fruit quality, and enhance overall profitability. The practice also helps extend the shelf life of bananas by preventing premature ripening and improving the fruit's appearance during transport and storage.

In summary, bunch covering is an important practice for improving fruit quality, ensuring food safety, and enhancing economic returns in banana production. It provides both environmental and pest protection, making it a vital component of integrated crop management, particularly in banana orchards where maintaining high-quality produce is essential for success in the market.

3.16 Harvesting

Source: KALRO 2022

Banana harvesting typically begins 9 to 18 months after planting, depending on the variety and growing conditions. Full production is usually reached within **2 to 3 years**. Harvesting involves carefully cutting the bunch from the plant once the bananas have reached their desired size and maturity.

For tall banana varieties, it may be necessary to cut the pseudostem in the middle to allow the bunch to be safely accessed and to prevent it from falling to the ground. This practice helps protect the bunch from damage and ensures the fruit can be harvested without injury.

In Kenya, the average yield of bananas is around 10 tons per acre. However, with improved management practices, yields can increase significantly, with the potential to reach 20 to 40 tons per acre. Factors such as proper irrigation, soil management, pest control, and crop care play a crucial role in achieving these higher yields and ensuring a productive banana crop.

3.16.1 Harvesting Indices in Banana Production

Harvesting indices are key indicators used to determine the right time for harvesting bananas to ensure the best quality and yield. These indices help farmers assess the maturity of the fruit and optimize harvest timing, leading to improved marketability and reduced post-harvest losses. Using clear and reliable indices is crucial for achieving optimal fruit quality, especially when bananas are being sold for consumption, processing, or export.

The importance of using harvesting indices lies in their ability to:

Ensure consistent fruit quality.

Prevent harvesting too early or too late, both of which can negatively impact taste, texture, and shelf life.

Improve marketability by providing bananas with the desired attributes.

Increase overall productivity and reduce waste by optimizing harvesting time.

Below are the key harvesting indices for bananas, which can be used to evaluate fruit maturity:

(i) Fruit Size

As bananas mature, the length and volume of the fruit increase. A mature banana should have reached its full size, as smaller fruits may indicate premature harvesting. Farmers can use a measuring tape or ruler to assess the size of the fruit and determine if it is large enough for harvest.

Index: A fully mature banana fruit should be at least 70-80% of its maximum expected length and volume, depending on the variety.

(ii) Fruit Shape

During the early stages of development, banana fruits are angular in shape, with noticeable ridges around the fingers.

As the fruit matures, the individual bananas begin to round out, and the ridges soften. The fingers become more smooth and rounded in cross-section.

Index: A well-matured banana will have smooth, rounded fingers with no prominent ridges. The transition from angular to rounded shape is an important indicator of maturity.

(iii) Peel and Pulp Color

The color of the peel is a key indicator of ripeness. As bananas mature, the peel changes from a deep green to a lighter green or yellow. However, bananas should be harvested while the peel is still predominantly green, as a fully yellow peel often indicates over-ripening.

The pulp color also changes during maturation. Immature bananas have a cream-colored pulp, while the pulp becomes more orange-yellow as it ripens.

Index: Harvest bananas when the peel is light green or just starting to show traces of yellow. The pulp should be firm and light yellow or cream-colored.

Using these harvesting indices helps ensure that bananas are harvested at the optimal stage of maturity. By evaluating fruit size, shape, and color, farmers can make more accurate decisions about the right time to harvest, improving both the quality and quantity of the crop. This approach is essential for maximizing marketability, reducing waste, and achieving higher profitability in banana production.

CHAPTER 4: PESTS, DISEASES AND MANAGEMENT

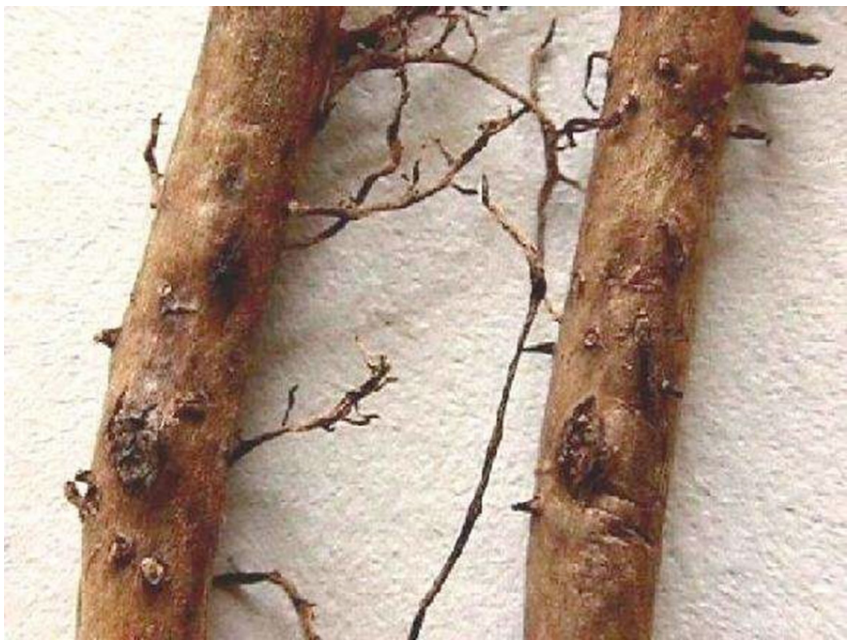
Effective management and control of pests and diseases are critical for successful banana production. Pests and diseases, can significantly reduce plant health, yield, and quality. Left unchecked, they can lead to severe damage, resulting in increased production costs and lower marketable output. Regular monitoring, early detection, and integrated pest management (IPM) strategies, including cultural, biological, and chemical control methods, are essential to minimize losses. By effectively managing pests and diseases, farmers can ensure healthy, high-yielding banana crops, improve profitability, and contribute to sustainable banana farming practices. Proper pest and disease control also helps protect the environment by reducing the need for excessive chemical treatments.

4.1 Major pests

The picture above illustrates common pests:

- Burrowing Nematode
- Banana Thrips
- Banana Weevil Borer
- Moles

4.2 Burrowing Nematodes



Nematodes are one of the most damaging pests in banana production, causing up to 70% loss of the crop.

4.2.1 Damages:

Nematodes create lesions and tunnels within the rhizome, leading to root destruction.

This root damage weakens the plant, making it prone to toppling, especially during windy conditions or when the plant is bearing fruit.

4.2.2 Control Measures:

Use clean planting material: Opt for disease-free tissue culture plantlets or treat suckers with hot water to reduce the risk of nematode infestation.

Incorporate green manure: Plant *Tithonia* (Mexican sunflower) and *Mexican Marigold* around the banana orchard to act as natural nematicides.

Apply organic manures: Use farmyard or poultry manure to enhance soil health and reduce nematode populations.

4.3 Banana Thrips

4.3.1 Damages:

Thrips cause silvery patches on banana fruits, which later turn brown.

In cases of heavy infestation, the skin of the fruit may crack, allowing secondary infections to develop, leading to fruit rot and reducing marketability.

4.3.2 Control Measures:

Remove male flowers: This helps to reduce thrips attraction to the plants.

Covering or bagging of bunches: This prevents thrips from accessing the developing fruit and reduces the risk of infestation.

Insecticides: Use insecticides like *Deltamethrin* (Decis 2.5 EC®) or *Pirimiphos-Methyl* (ACTELLIC 25 EC®) to control thrips populations.

By employing these management strategies, farmers can reduce thrips damage and improve the quality and marketability of their banana crops.

4.4 Banana Weevil (Banana Borer)

4.4.1 Identification:

Adult Weevil: A brown-black weevil with a curved, hard shell.

Borer (Grub): The larvae form irregular tunnels in the rhizome, reducing it to a mass of rotting tissue.

4.4.2 Damages:

Infested plants exhibit yellowing of the leaves, premature wilting, and eventual death of the plant.

Infested plants become weak and are more easily blown over by wind.

4.4.3 Control Measures:

Use clean planting material: Ensure that planting materials, such as tissue culture plants or hot water-treated suckers, are free from weevils.

Avoid leaving planting materials in the field overnight: This helps prevent the weevil from laying eggs on the suckers.

Post-harvest management: After harvesting, cut stems at ground level and cover the cut surfaces with soil to prevent weevils from entering.

Proper disposal: Cut harvested banana stems into small pieces to promote faster drying and rotting, reducing the likelihood of weevil infestation.

Effective management of the banana weevil helps to reduce plant loss, ensuring healthier crops and higher yields.

4.5 Moles

4.5.1 Identification:

Moles are small, cylindrical mammals with velvety fur.

They have tiny or almost invisible ears and eyes.

Their short, powerful limbs are equipped with large paws, adapted for digging.

Moles create mounds of soil that are typically shaped like volcanoes, and may also leave surface tunnels.

4.5.2 Damages:

Moles can cause damage to banana plants by tunneling around the root zone, leading to the collapse of banana stools due to root damage.

4.5.3 Control Measures:

Moisture management: Keep the soil around the banana stools consistently moist, as moles prefer dry, loose soil and are less likely to inhabit wet areas.

Avoid heaping soil around the stool basin: This can provide a hiding place for moles and encourage infestation.

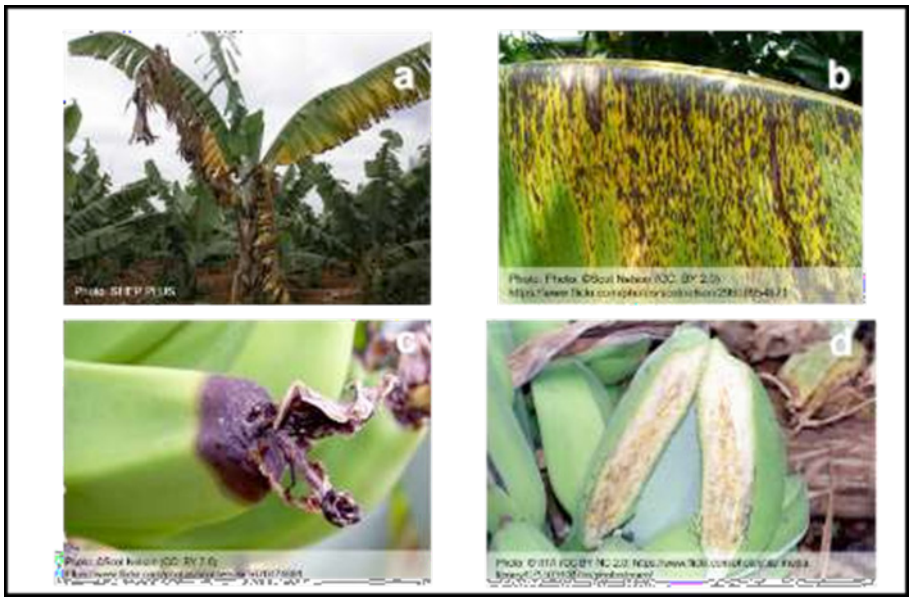
Trapping: Use traps with bait to capture and remove moles from the farm.

By managing soil moisture and eliminating potential hiding spots, farmers can reduce the risk of mole damage and maintain healthy banana plants.

Photo: By Scapanus_latimanus.jpg: Sarah Murray derivative work: WolfmanSF (Scapanus_latimanus.jpg) [CC BY-SA 2.0 (http://creativecommons.org/licenses/by-sa/2.0)], via Wikimedia Commons

4.6 Major Diseases

Banana production in Kenya faces significant challenges from various diseases that can cause substantial yield losses. Major diseases affecting bananas include Panama Disease (Fusarium Wilt), Black Sigatoka, Cigar End Rot, Banana Bacterial Wilt (BBW), **and** Bunchy Top Disease. According to a 2010 KALRO report, banana diseases account for an estimated 25% loss in production, a figure that is exacerbated by the warm, wet conditions typical of banana-growing regions. These diseases not only affect the plants in the field but also continue to pose threats during harvesting and post-harvest handling, leading to further economic losses. The impact of these diseases can reduce fruit quality, lower marketability, and result in significant financial setbacks for farmers. Effective disease management is critical for maintaining healthy banana crops and ensuring sustained production and profitability within the banana value chain.



4.7 Banana Wilt Disease (Fusarium Wilt)

4.7.1 Description:

Banana Wilt, commonly referred to as **Fusarium Wilt**, is a soil-borne disease caused by the fungus *Fusarium oxysporum* f.sp. *cubense*. This pathogen primarily infects the banana plant's vascular system, blocking the flow of water and nutrients, which leads to wilting and eventual death of the plant. The disease is considered one of the most destructive banana diseases globally, and it affects plants at all stages of growth, often with devastating economic consequences.

4.7.2 Symptoms:

Yellowing of Older Leaves: The first sign of Fusarium Wilt is the yellowing of the older leaves at the base of the plant. These leaves begin to collapse while still remaining green at the base.

Progressive Wilting: As the disease progresses, the older leaves continue to turn yellow, shrivel, and fall off in a characteristic sequence—from the oldest to the youngest leaves. This leaves the plant looking like it is wearing a "skirt" of hanging dry leaves around the pseudo-stem.

Heart Leaf Death: The heart leaf, which is the newest emerging leaf, may die before it unfurls fully, resulting in stunted growth.

Pseudo-Stem Collapse: The plant may continue to stand upright initially, but as the disease progresses, the pseudo-stem becomes weakened and eventually falls over, often prematurely.

Failure to Produce Fruit: Infected plants often fail to produce normal bunches of bananas. The fruit stalk may not develop properly, and if it does, the fruit is typically of poor quality or immature before the plant dies.

Increased Susceptibility in Certain Varieties: Varieties like **Apple** and **Gross Michel/ Kampala** are highly susceptible to Fusarium Wilt, making them more vulnerable to infection in areas where the disease is prevalent.

4.7.3 Control and Management:

i) Use of Resistant Varieties:

The most effective long-term control of Fusarium Wilt is to plant resistant varieties. Some varieties have shown resistance to the disease, including **Giant Cavendish**, **Lacatan**, and various **FHIA hybrids** (such as FHIA-01, FHIA-17, and FHIA-23).

iiii**) Disease-Free Planting Material:**

Use certified, disease-free planting material, such as Tissue Culture plants or clean sword suckers. Tissue-cultured plants are propagated under controlled laboratory conditions and are free from most common soil-borne pathogens, including *Fusarium*.

Suckers obtained from disease-free plants should be carefully inspected and treated (e.g., hot water treatment) before being used for planting to reduce the risk of spreading Fusarium Wilt.

iii) Field Sanitation and Quarantine:

Quarantine measures should be enforced to prevent the movement of contaminated plant materials into healthy fields. Infected plants, including suckers, leaves, and corms, should be destroyed and carefully disposed of to prevent the fungus from spreading.

Tools, machinery, and other equipment should be cleaned thoroughly after use in infected areas to avoid cross-contamination.

Field rotation and resting are important. Fields should not be replanted with bananas for several years if Fusarium Wilt has been present, as the fungus can remain in the soil for many years.

iv) Soil and Field Management Practices:

Practices such as crop rotation with non-host crops (e.g., legumes, cereals) can help break the disease cycle by reducing the build-up of *Fusarium* spores in the soil.

Soil sterilization and improved drainage in fields can also help minimize the disease, as *Fusarium* prefers moist, poorly drained soils.

v) Monitoring and Early Detection:

Regular monitoring of banana fields for signs of Fusarium Wilt is essential for early detection. Immediate action should be taken to remove infected plants before the disease can spread to healthy plants.

4.7.5 Economic Impact:

Fusarium Wilt is one of the most economically damaging banana diseases, as it leads to reduced yield, premature death of plants, and loss of fruit quality. The disease severely impacts banana production in tropical regions, and in severe cases, entire banana plantations may need to be abandoned. This, in turn, results in significant financial losses for farmers and disruptions to the banana supply chain, which affects both local and international markets.

By adopting resistant varieties, using disease-free planting material, and implementing good field hygiene, farmers can significantly reduce the risk of Fusarium Wilt and improve the sustainability of their banana farming operations.

4.8 Black Sigatoka (Black Leaf Streak)

4.8.1 General Description:

Black Sigatoka, also known as **Black Leaf Streak**, is one of the most devastating fungal diseases of banana plants, caused by the pathogen *Mycosphaerella fijiensis*. This disease is widespread in banana-growing regions, especially in the tropics, and has severe implications for both yield and fruit quality. Black Sigatoka primarily affects the leaves of banana plants, leading to premature leaf death, reduced photosynthetic capacity, and ultimately, lower yields. It is a particularly important concern for commercial banana producers, as it can significantly reduce the productivity and profitability of banana farming.

4.8.2 Symptoms:

Leaf Streaks: The most characteristic symptom of Black Sigatoka is the appearance of dark streaks or lesions on the leaves. Initially, the lesions appear as small, dark, and water-soaked spots that gradually enlarge, often merging together into larger streaks.

Yellowing and Necrosis: As the disease progresses, the tissue around the lesions turns yellow, and the affected leaves begin to die back prematurely. The leaves often become necrotic, turning brown or black, and eventually dry up.

Defoliation: In severe cases, entire leaves may die and fall off. This leads to **defoliation**, which reduces the plant's ability to perform photosynthesis and hampers the development of the fruit bunch.

Reduced Yield and Fruit Quality: As the disease progresses, it affects the overall health of the plant, reducing the number of functional leaves available for photosynthesis, which impacts the size and quality of the banana bunches. Infected plants may also produce fruit that is smaller and of lower quality.

Blackened Ribs and Streaks: Older leaves may develop dark black streaks that run along the veins of the leaves, and the **ribs** may become distinctly blackened. This is the most noticeable sign in advanced stages of the disease.

4.8.3 Control and Management:
Black Sigatoka can be effectively managed through a combination of **cultural practices**, **resistant varieties**, and **chemical control**. However, managing the disease requires a proactive, integrated approach to minimize its impact.

Use of Resistant Varieties:

Some banana varieties, such as **FHIA hybrids** (e.g., **FHIA-01**, **FHIA-17**) and certain **Cavendish** types, exhibit resistance or tolerance to Black Sigatoka. Planting resistant varieties helps minimize the risk of infection and the subsequent impact on yield.

Sanitation and Field Hygiene:

Regular removal of infected leaves: Infected banana leaves should be regularly removed from the plantation and destroyed to prevent the spread of the disease. Diseased material can serve as a source of infection for other plants in the field.

Proper spacing of plants: Adequate spacing between banana plants helps ensure good air circulation, which reduces the humidity levels that favor the development of Black Sigatoka.

Field rotation: Although Black Sigatoka mainly spreads through rainwater and wind, rotating banana crops with non-host plants, such as legumes or cereals, can reduce the risk of disease buildup in the soil.

Fungicide Application:

Regular **fungicide spraying** is one of the primary methods of managing Black Sigatoka. Fungicides such as **Propiconazole**, **Chlorothalonil**, and **Copper-based fungicides** have proven effective in controlling the spread of the disease. Fungicides should be applied according to recommended schedules to maintain effective protection.

Integrated Pest and Disease Management (IPDM) strategies should be employed, which may involve combining fungicide applications with other cultural practices like sanitation and the use of resistant varieties to manage disease more sustainably.

Nutrient Management:

Adequate **nutrition** is essential for healthy banana plants, as nutrient deficiencies can make plants more susceptible to disease. A balanced supply of **nitrogen**, **potassium**, and **phosphorus** helps maintain the plant's immune system and strengthens its resistance to diseases like Black Sigatoka.

Micronutrients, such as **zinc** and **manganese**, are also crucial in boosting the plant's defense mechanisms.

Water Management and Drainage:

Black Sigatoka thrives in humid, wet conditions. Therefore, it is important to maintain **proper drainage** in banana fields to avoid excess moisture buildup. Irrigation systems should be managed carefully to prevent waterlogging, which promotes fungal growth.

If possible, planting bananas in areas with adequate rainfall but good natural drainage is ideal.

Quarantine and Disease-Free Planting Material:

As with many other banana diseases, Black Sigatoka can be introduced into new areas via infected plant material. **Tissue-cultured banana plants** or other certified disease-free materials should be used for planting to ensure that the disease is not introduced into new fields.

Quarantine measures should be strictly observed when introducing new plants or moving materials between farms to prevent disease spread.

4.8.4 Economic Impact:

Black Sigatoka has a **significant economic impact** on banana production. Infected plants experience reduced yields due to the loss of photosynthetic capacity, and the fruit produced is often of lower quality, which affects market prices. If left unmanaged, Black Sigatoka can lead to the total loss of banana production in severely affected fields. Farmers in banana-producing regions are often forced to apply costly chemical controls to manage the disease, which increases the overall cost of banana production. These added costs, combined with lower yields and fruit quality, result in considerable financial losses, particularly for smallholder farmers who may lack the resources for regular fungicide applications.

4.8.5 Conclusion:

Black Sigatoka is a serious threat to banana production, but with early detection and a combination of resistant varieties, good field management practices, and effective fungicide application, its impact can be significantly reduced. By following these management strategies, banana farmers can improve their chances of maintaining healthy banana plantations, ensuring better yields and higher fruit quality for the market.

Photo: Olaf Nielsen (CC BY 2.0)
https://www.flickr.com/photos/olafnielsen/2903854401

4.9 Cigar-End Rot (Verticillium theobromae)

4.9.1 General Description:

Cigar-end rot is a significant fungal disease of bananas caused by *Verticillium theobromae*. The disease is commonly found in banana-growing regions worldwide, where it affects the developing fingers of banana plants, especially during the early stages of fruit emergence. Cigar-end rot causes a characteristic dry rot at the flower end of the fruit, resulting in an ashy gray, wrinkled lesion that resembles the burnt end of a cigar. This distinctive appearance gives the disease its name. While the disease is most visible during the early fruit development phase, it can also progress and affect the entire fruit during storage or transportation.

4.9.2 Disease Cycle:

The pathogen enters the banana finger through the flower (perianth) and infects the tip of the immature fruit. The infection typically starts at the flower end of the finger and spreads as the fruit grows. Spores of *Verticillium theobromae* (conidia) are spread primarily through air currents, which means that infection is most likely to occur during the early days of fruit emergence when environmental conditions are conducive to fungal growth.

As the banana fruit develops, the fungus causes black necrosis to spread from the perianth into the tip, leading to a dry rot. The affected tissue becomes covered by a powdery mass of fungal spores, which gives it the characteristic grayish appearance, resembling ash or the burnt tip of a cigar. This rot can spread slowly along the length of the fruit as it matures, affecting the fruit's appearance and marketability. If the infection is severe, the entire banana finger may rot.

Cigar-end rot is more common in **warm, moist conditions** and is especially prevalent in **high-altitude areas** or plantations that experience excessive shade, which creates the humid microclimate favorable for the disease.

4.9.3 Symptoms:

Black Necrosis: The first visible symptom is a black necrotic area that starts at the flower end of the banana and extends into the tip of the fruit.

Dry Rot: The affected tissue becomes dry and shriveled, and the fruit pulp undergoes a dry rot that spreads from the tip. This rot is typically dry and does not result in a soft, mushy texture.

Ashy Appearance: As the rot progresses, the affected part of the fruit becomes covered with a mass of fungal mycelia, giving the fruit the characteristic **gray, ash-like appearance** at the tip, which looks like a cigar end.

Rejection in the Market: The presence of this rot causes bananas to become unattractive and unmarketable. The affected fingers are often rejected in the market due to their unappealing appearance.

4.9.4 Disease Management:

Effective management of cigar-end rot is essential to reduce losses in banana production. Both **chemical** and **non-chemical** methods can be employed to control the disease.

Chemical Control:

Fungicides can be used to control and prevent the spread of cigar-end rot. Some of the recommended fungicides include:

- RANSOM 600WP – 15g/20l
- ABSOLUTE 375SC – 10ml/20l
- EXEMPO CURVE 250SC – 15ml/20l
- EXPLORER 3 SL – 10ml/20l
- KATERINA 720SC – 40ml/20l
- MEGAPRODE LOCK 525WP – 20g/20l
- MILESTONE 250SC – 10ml/20l
- PROVIDENCE 400WP – 50g/20l

- RIMETA GOLD 300SC – 40ml/20l
- TRINITY GOLD 425WP – 50g/20l
- CHARIOT 500SC – 20ml/20l

Application Guidelines:

Fungicides should be mixed with **INTEGRA** (3ml/20l) to enhance the efficacy of the treatment. INTEGRA acts as a **sticker, spreader, wetter, and penetrant**, which improves the fungicide's ability to adhere to the plant surface and penetrate the fungal cells.

Fungicides should be applied at **regular intervals (every 1-2 weeks)**, particularly during the fruit emergence period and when weather conditions are conducive to fungal growth.

Alternating fungicides during the growing season is crucial to prevent the development of fungal resistance to any one fungicide.

4.9.5 Non-Chemical Control:

In addition to fungicide applications, several cultural practices can significantly reduce the incidence of cigar-end rot:

Use Disease-Free Planting Material:

Always ensure the use of **healthy, disease-free planting materials**, such as clean tissue culture plants or properly treated suckers, to minimize the introduction of pathogens into the field.

Field Sanitation:

Remove dead or hanging leaves from banana plants regularly. These leaves may harbor fungal spores and contribute to the spread of disease.

Clean packing stations and ripening rooms to minimize the chances of post-harvest infestation. Keeping these areas free of plant debris and fungal spores is essential for controlling the disease during handling and transport.

Fruit Protection:

Bagging of banana bunches during the fruiting stage can help protect the developing fruit from airborne fungal spores.

Remove untransformed male flowers that appear after fruit emergence to reduce moisture accumulation, which can favor fungal growth.

Avoid Fruit Damage:

Handle bananas gently during harvesting and transport to avoid physical injury to the fruit, which can provide entry points for the fungus.

Deflower the bunches approximately **8-11 days after fruit emergence** to reduce the risk of infection through the flower end.

Proper Nutrition:

Properly **fertilize and manage plant nutrition** to maintain strong, healthy plants. Healthy plants are better equipped to resist diseases and tolerate stress, including fungal infections like cigar-end rot.

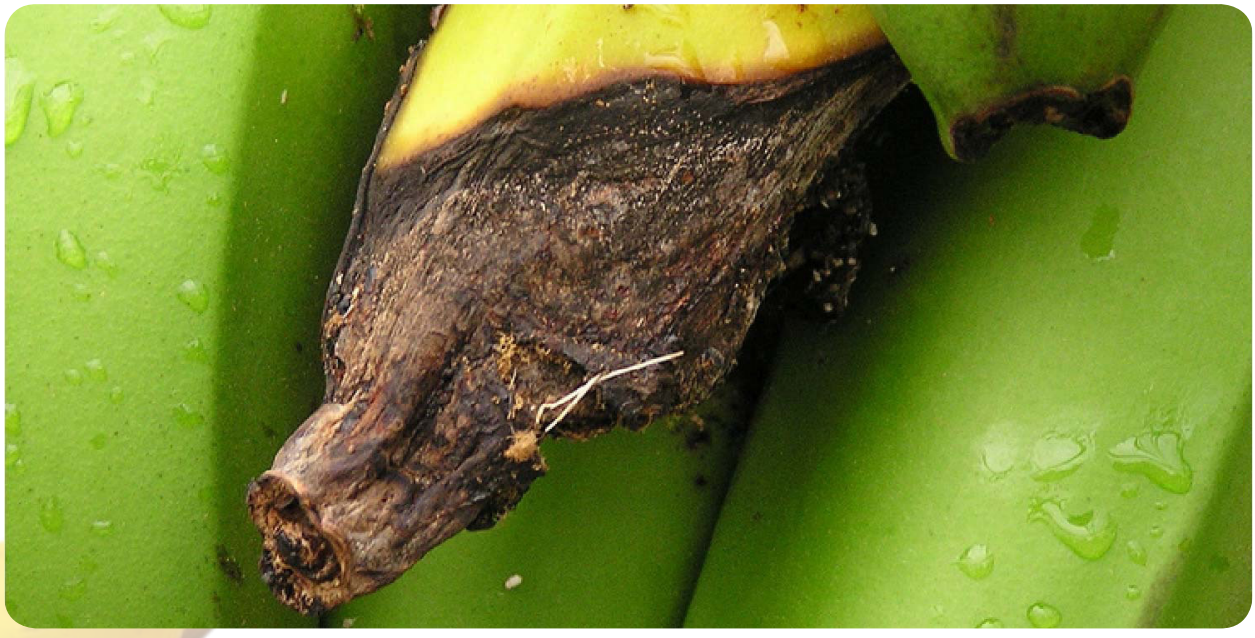
4.9.6 Economic Impact:

While cigar-end rot does not typically result in total crop loss, it significantly reduces the **marketability** of affected bananas. The unattractive appearance of the fruit leads to **rejection in**

local and export markets, reducing the farmer's income. Additionally, the need for extra labor and chemicals for disease control, combined with potential loss of quality, represents a significant economic burden. Thus, timely and effective disease management is crucial for maintaining profitability in banana farming.

4.9.7 Conclusion:

Cigar-end rot, caused by *Verticillium theobromae*, is a preventable and manageable disease that can cause significant post-harvest losses if not controlled. By combining **cultural practices** (such as field sanitation, bagging, and proper handling) with effective **chemical control** measures (including fungicide applications), farmers can reduce the incidence of cigar-end rot and protect the quality and marketability of their bananas. Regular monitoring and timely intervention are key to minimizing the impact of this disease.



Images showing Cigar end rot infestation (Source: Greenlife 2023).

4.10 Banana Bacterial Wilt (BBW)

Identification:
Banana Bacterial Wilt is caused by *Xanthomonas campestris* pv. *musacearum*. It affects the entire banana plant, leading to wilting and death.

Symptoms:

- The leaves develop water-soaked lesions, which later turn yellow.
- Black streaks appear on the stem, and the fruit may ripen prematurely.
- Plants collapse, and the disease can spread rapidly in infected fields.

Control:

- Use of disease-free planting material (preferably tissue-cultured plants).
- Sanitize tools and equipment to prevent contamination.
- Remove and destroy infected plants to prevent further spread.
- Implement quarantine measures to restrict movement of infected materials.

Banana fruit infected with ***Xanthomonas*** "Bacterial Wilt"

Banana pseudostem showing *Xanthomonas* wilt infection Source KALRO 2022).

4.10.1 General Description:

Bacterial wilt is easily spread through the use of infected planting materials and contaminated farm tools.

It is transmitted by insects, including bees, which can spread the bacteria through the male bud.

The *Lacatan* variety is particularly susceptible to bacterial wilt.

4.10.2 Symptoms:

Withering of flowers, wilting of leaves, and premature ripening of fruits.

The leaf sheath becomes dull green, scalded, and breaks at the petiole, causing the collapse of all leaves on the pseudo-stem.

A cross-section of the pseudo-stem reveals yellow discoloration and bacterial ooze.

Fruits ripen unevenly and prematurely.

4.10.3 Control Measures:

Field Sanitation:

Disinfect farm tools after use and wash hands (e.g., using a 1:5 ratio of bleach to water).

Uproot, destroy, and bury affected plants to prevent further spread.

Disbudding:

Remove male flower buds after fruiting to reduce the risk of infection.

Quarantine:

Implement quarantine measures to prevent the introduction and spread of the disease.

Use of Clean Planting Materials:

Ensure that only healthy, disease-free planting materials are used.

CHAPTER 5: GREEN TECHNOLOGIES AND MECHANIZATION

The banana value chain in Kenya plays a vital role in the country's agricultural economy, providing livelihood to thousands of farmers and contributing significantly to food security. However, as global demand for bananas grows and the challenges of climate change, pests, and disease intensify, the need for innovative solutions has never been more urgent.

Green technologies and mechanization offer a promising pathway to enhance the efficiency, productivity, and sustainability of banana production. By integrating environmentally friendly practices and advanced machinery into banana farming, farmers can reduce their dependency on harmful chemicals, lower production costs, and increase yields while safeguarding the environment.

Green technologies—such as integrated pest management, organic farming practices, and renewable energy solutions—help to mitigate environmental degradation, reduce the carbon footprint, and ensure the long-term health of banana farming ecosystems. Meanwhile, mechanization, through tools like banana harvesters, plant and soil management equipment, and automated irrigation systems, can significantly streamline labor-intensive processes, reduce waste, and improve overall operational efficiency.

In this context, adopting green technologies and mechanization not only boosts the competitiveness of Kenya's banana industry but also supports the broader goal of sustainable agricultural development. By empowering farmers with the tools and knowledge to embrace these innovations, Kenya can position itself as a leader in sustainable banana production while improving the livelihoods of its farming communities.

5.1 Minimal and Zero Tillage

Minimal Tillage involves preparing only planting basins or rip lines rather than fully plowing the soil. This method helps reduce soil erosion, compaction, and the formation of plough pans. Farmers can prepare larger areas, enabling faster planting at the onset of the rains. By concentrating rainfall, fertilizers, and manure into these planting zones, minimal tillage enhances soil fertility and moisture retention.

Zero Tillage is a system where the soil is left undisturbed from harvest to seeding. Only minimal disturbance is made during planting. This technique prevents the germination of weed seeds, reduces soil erosion by water and wind, and helps in carbon sequestration by preventing the release of CO2 from the soil. Zero tillage contributes to reduced emissions, making it a key practice for mitigating climate change.

5.2. Macro Propagation

Macro propagation is a cost-effective technique for multiplying healthy, disease-free banana planting materials. By using sword suckers, maiden suckers, and corms from selected banana plants, farmers can produce large quantities of clean planting material. This method uses locally available media like sawdust for propagation and promotes the use of disease-free planting material, ensuring healthier banana orchards and reducing the spread of pests and diseases.

5.3. Paring and Hot Water Treatment

This is an essential practice for ensuring pest- and disease-free planting material. By pairing and subjecting banana planting materials to hot water treatment, farmers can eliminate soil-borne pests

such as nematodes and weevils. This practice is critical for maintaining healthy banana plants and ensuring higher productivity.

5.4. Drought and Disease-Tolerant Varieties

Varieties such as *Williams* and *Chinese Cavendish* are bred to tolerate drought conditions and perform well even under irregular rainfall. These varieties are also resistant to key diseases such as Fusarium wilt (race 1 and 2). In addition, the *PHIA* series offers resistance to Black Sigatoka, while *GT Kisii* is promoted for its tolerance to Panama disease. These varieties provide a sustainable solution for climate resilience in banana farming.

5.5. Mulching

Mulching involves covering the soil with organic materials such as leaves, straw, or compost. This practice helps to retain soil moisture, suppress weeds, regulate soil temperature, and prevent soil erosion. Mulching also enhances soil fertility by improving the physical, chemical, and biological properties of the soil, thus supporting the growth of bananas and increasing overall crop yield.

5.6. Intercropping

Intercropping involves growing two or more crops on the same piece of land, typically bananas and legumes, to maximize land use. This system not only increases land productivity but also improves soil fertility through nitrogen fixation. Additionally, legumes act as cover crops, enhancing soil structure and preventing soil erosion. The integration of legumes helps improve banana productivity and provides farmers with additional food and income sources.

5.7. Zai Pits

Zai pits are small, water-holding planting pits that improve water retention in dry areas. Typically measuring 60–90 cm wide and 60–80 cm deep, these pits are filled with organic materials like compost or manure to provide essential nutrients. Zai pits are particularly useful in drought-prone areas, especially in the ASAL (Arid and Semi-Arid Lands) regions, where rainfall is unpredictable.

5.8. Drip Irrigation

Drip irrigation is a water-efficient method that delivers water directly to the plant root zone using drip lines and emitters. This technology minimizes water wastage and optimizes water usage, especially in areas with limited water resources. Drip irrigation systems can also be integrated with fertigation, allowing farmers to apply fertilizers efficiently. This system boosts crop yields, conserves water, and enhances overall farm productivity.

5.9. Use of Green Manure

Green manure involves the use of nitrogen-fixing plants, either as part of crop rotation or intercropping with bananas. These plants, such as legumes, help enrich the soil by fixing nitrogen, a vital nutrient for plant growth. Incorporating green manure into the soil enhances soil fertility, improves banana productivity, and reduces the need for synthetic fertilizers.

5.10. Integrated Pest Management (IPM)

IPM is an environmentally sustainable approach to pest and disease control that combines cultural, biological, and chemical methods. This includes practices such as pairing and hot water treatment of suckers to control nematodes and weevils, pruning to enhance air circulation, and using cover crops to suppress weeds. IPM also incorporates the use of biological controls like bionematodes and careful monitoring to reduce pesticide use, thus minimizing environmental impact.

5.11. Banana Bagging

Banana bagging involves placing translucent polythene bags around banana bunches to protect them from pests and diseases, especially thrips. Early bagging, which involves placing the bags before the bananas have fully developed, is especially effective in preventing damage. The bags allow for better light transmission while preventing UV rays from causing fruit damage, and they help in producing larger, more marketable bunches. Biodegradable bagging options are also available, further promoting sustainability.

5.12. Post-Harvest Banana Packaging

Proper post-harvest packaging is crucial to reducing banana fruit damage during transport. Using banana leaves for packaging helps cushion the fruit against bruising and shrinkage, especially when transporting bananas over long distances. Improper packaging can result in significant losses (up to 30% or more), due to breakages, bruising, and spoilage caused by environmental factors. Proper packaging enhances banana shelf life and ensures better market value.

5.13. Zero Energy Brick Cooler (ZEBC)

The Zero Energy Brick Cooler is an innovative low-cost post-harvest technology that improves the shelf life of bananas by maintaining a cooler environment without the need for electricity. The cooler operates on the principle of evaporative cooling, where water evaporation from porous materials such as bricks lowers the temperature inside the cooler, extending the shelf life of the bananas by up to two weeks. This technology is especially useful for small-scale farmers who lack access to refrigeration systems.

5.14 Mechanization of Banana Farming Operations

Mechanization in banana farming has become increasingly vital as the area of banana production expands. The primary reasons for mechanization include rising labor costs, the need for product quality improvement, the demand to meet food safety standards, and the pressure from both domestic and international markets to remain competitive. Mechanization helps reduce crop losses, improve efficiency, and respond to the growing demand for bananas.

As the banana industry in Kenya continues to grow, mechanization is crucial to improving farm productivity, addressing labor shortages, and ensuring quality standards. Mechanized tools, implements, and machines help streamline labor-intensive processes, reduce the time spent on manual tasks, and ultimately increase yields. These technologies can be powered by solar energy, hand and draft animals, or motorized engines. Given the rapid population increase and the need to feed a growing population, mechanization is essential to sustainably improve banana productivity.

5.15 Key Machines and Tools in Banana Farming:

Manure Spreader:

Role: The manure spreader is used to efficiently distribute organic fertilizers (e.g., manure, compost) over large areas. This machine ensures even application of organic matter, which improves soil fertility, promotes healthy banana growth, and enhances yield. By reducing the labor required for manual application, it increases efficiency and reduces the time needed to prepare fields.

Plastic Mulch Layer:

Role: This machine lays down plastic mulch over the soil to create a protective barrier. Plastic mulch helps retain moisture, suppress weeds, regulate soil temperature, and reduce soil erosion. It is particularly useful in areas with erratic rainfall, as it conserves water and creates optimal growing conditions for bananas. The use of plastic mulch also helps in reducing the need for chemical weed control, promoting sustainable farming practices.

Rip Line Laying Machine:

Role: This machine is used to prepare rip lines for planting banana suckers or tissue-cultured plants. Rip lines are shallow trenches that help concentrate water, fertilizers, and organic matter in specific areas for plant growth. The rip line laying machine saves time and ensures precise placement, which improves plant establishment and enhances banana yields.

Pit Hole Digger (Auger):

Role: The pit hole digger, or auger, is used to drill holes for planting banana suckers or other crops. The auger makes the process faster and more uniform compared to manual digging, ensuring the correct depth and width for planting. It reduces labor costs and ensures consistent planting depth, which is crucial for healthy banana growth.

Trencher:

Role: A trencher is used to create trenches in the soil for various purposes, such as irrigation or planting. In banana farming, a trencher can be used for planting banana suckers, laying irrigation lines, or preparing soil for drainage. This machine ensures precise trenching, which improves soil aeration and water distribution, key factors in maintaining healthy banana plants.

Seed Drill/Planter:

Role: The seed drill or planter is used for planting banana suckers or other crops with accuracy. This machine plants the suckers at the correct spacing and depth, which helps in reducing plant competition, promoting proper growth, and maximizing banana yields. The planter can be set to plant in rows, optimizing space and making field management easier.

Power Weeder:

Role: The power weeder is used to control weeds around banana plants. Weeds compete for water, nutrients, and light, which can reduce banana yields. The power weeder reduces the need for manual weeding, saving time and labor costs. It is especially useful in large-scale banana plantations and can be used to weed between the banana rows, ensuring a clean and healthy growing environment.

Air Blast Sprayer:

Role: The air blast sprayer is used for applying pesticides, fungicides, and fertilizers to banana plants. This machine uses air pressure to spray chemicals over large areas, ensuring even coverage on banana leaves and bunches. It is especially effective in controlling pests like aphids, thrips, and the spread of fungal diseases such as Black Sigatoka. The air blast sprayer helps minimize pesticide usage by ensuring accurate and efficient application.

Pruner:

Role: The pruner is used to trim and maintain banana plants by removing dead leaves, suckers, and excess growth. Regular pruning helps improve air circulation, reduce disease buildup, and direct the plant's energy toward producing more fruit. Using a pruner instead of manual labor speeds up the process and ensures more precise cuts, leading to healthier banana plants and higher yields.

Banana Harvester:

Role: The banana harvester is a mechanical tool used to efficiently harvest banana bunches. The harvester reduces the need for manual labor during the harvesting process, which can be physically demanding and time-consuming. With a harvester, farmers can reduce crop losses, improve the efficiency of the harvesting process, and ensure that bananas are picked at the optimal stage for marketability. This machine helps to reduce post-harvest losses, especially for farmers who harvest large quantities.

5.16 Benefits of Mechanization in the Banana Value Chain:

Increased Efficiency and Productivity: Mechanization reduces the time and labor needed for various tasks, allowing farmers to handle larger areas with fewer resources. This leads to higher productivity per unit of land.

Cost Savings: While the initial investment in machinery can be high, mechanization reduces labor costs over time and improves the quality of farm operations, resulting in long-term savings.

Improved Quality and Consistency: Machines like the air blast sprayer, pruner, and harvester ensure precision in application, maintaining consistency and improving the overall quality of the banana crop. This meets both domestic and international market standards for quality and food safety.

Reduced Crop Losses: Mechanized systems like the banana harvester and manure spreader help reduce crop losses during harvesting and application of inputs, ensuring more bananas reach the market in optimal condition.

Enhanced Competitiveness: As the banana sector faces increasing competition both locally and globally, mechanization helps farmers scale up production while maintaining quality, giving them a competitive edge in the marketplace.

Sustainability: By optimizing resource use (e.g., water, fertilizer, labor), mechanization promotes more sustainable farming practices, contributing to the long-term health of banana plantations and surrounding ecosystems.

5.17 Conclusion:

The adoption of mechanization in banana farming is essential for addressing the challenges posed by rising labor costs, increased competition, and the growing demand for higher productivity. By incorporating machines such as manure spreaders, plastic mulch layers, power weeders, and harvesters, banana farmers can significantly improve the efficiency, quality, and sustainability of their operations. Mechanization is not just about increasing output—it is about creating a more sustainable and profitable banana value chain that meets the needs of farmers, consumers, and the environment.

Land preparation by hand compared to preparation by tractor

Hole digging by hand

Hole digging by auger

Manure spreaders (Source ShepPlus 2018)

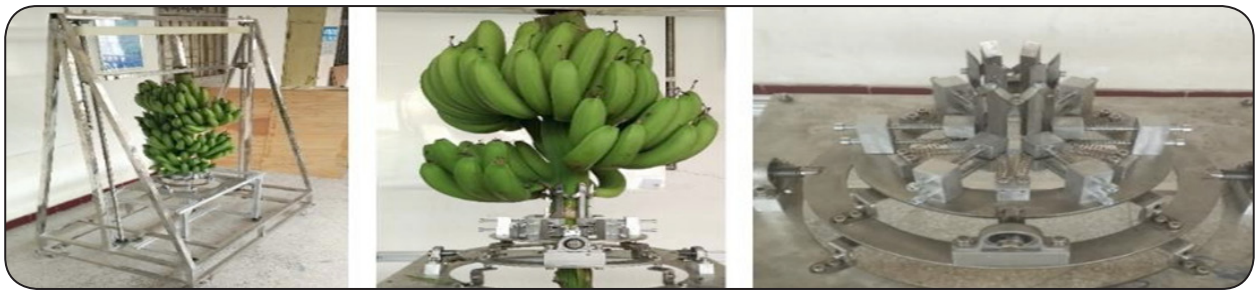
Innovative Banana propping

Mechanized banana Weeding (Source: Shep Plus)

Banana pseudostem choppers (Source ShepPlus, 2018)

Harvesting mechanization

Mechanical harvesters (Source: ShepPlus 2018)



Banana dehanding machine (Source: ShepPlus 2018)

CHAPTER 6: POST HARVEST MANAGEMENT AND VALUE ADDITION

6.1 Post-Harvest Management and Value Addition in the Banana Value Chain

Post-harvest management is a critical component in the banana value chain, focusing on maintaining the quality and quantity of harvested produce from the point of harvest to consumption. Proper post-harvest handling ensures that bananas retain their nutritional value, are safe for consumption, and experience minimal loss in quality and quantity. Effective post-harvest practices are vital for reducing food losses and waste, optimizing the value of the banana crop, and improving profitability for farmers and stakeholders across the banana industry.

6.1.1 Post-Harvest Losses

Post-harvest losses refer to the deterioration of the banana crop after harvesting, affecting both the quality and quantity of the produce. **Quality loss** encompasses degradation in nutrient content, flavor, texture, and appearance, which can reduce the banana's acceptability and edibility. **Quantity loss** refers to the decrease in the total amount of bananas available for consumption, which may occur due to physical damage, spoilage, or improper handling. These losses are often caused by factors such as inadequate storage conditions, poor handling, and delays in transportation.

To mitigate these losses, the goal of post-harvest management is to preserve the quality of bananas, ensure food safety, and reduce both quality and quantity losses. This includes adopting proper handling, storage, and packaging techniques, as well as implementing practices that extend shelf life and reduce the risk of spoilage.

6.1.2 Food Loss and Food Waste

Food loss and waste (FLW) represent significant challenges in the banana industry. **Food loss** occurs when bananas are spilled, spoiled, or otherwise lost before reaching the retail stage of the supply chain, typically due to poor handling, inadequate cooling, or improper storage conditions. On the other hand, **food waste** refers to bananas that are of good quality and fit for consumption but are discarded at the retail or consumption stage due to factors like oversupply, improper storage, or market preference for only certain types of bananas (e.g., ripe versus unripe).

Both food loss and food waste have direct economic impacts on farmers and businesses and contribute to environmental sustainability challenges. By addressing the causes of FLW, particularly at the pre- and post-harvest stages, farmers and businesses can improve banana supply chain efficiency, reduce losses, and enhance the economic value of the crop.

6.1.3 Critical Loss Points in Banana Post-Harvest Systems in Kenya

In Kenya, the banana post-harvest system faces several challenges that contribute to significant losses. These include:

Insufficient Pre-Harvest Conditions: Poor field management practices, such as inadequate pest and disease control, can lead to weak plants that are more susceptible to damage during harvest and transportation.

Inadequate Cooling: Bananas are highly perishable, and without proper cooling systems, such as refrigeration or cool storage, bananas can deteriorate quickly after harvest, especially in hot climates. Lack of cooling facilities results in rapid ripening, which reduces the shelf life of bananas.

Lack of Sorting and Grading: Failure to sort bananas before storage or transportation leads to the mixing of damaged or overripe fruits with healthy ones. Sorting helps remove defective bananas, ensuring that only the best quality fruit reaches the market.

Inadequate Postharvest Handling and Facilities: Poor handling techniques during harvesting, transport, and storage can result in physical damage such as bruising and cutting, which leads to increased spoilage. Inadequate storage facilities, including poor hygiene and lack of pest control, further contribute to post-harvest losses.

Inappropriate Packaging Materials: The use of substandard or inadequate packaging materials can cause bananas to be exposed to damage or environmental conditions that speed up ripening and decay. The use of appropriate packaging materials, such as ventilated bags or crates, helps protect the fruit during handling and transportation.

Inappropriate Processing and Preservation Methods: Inadequate or improper preservation techniques, such as drying, ripening, or fermentation, can result in the loss of nutritional value or quality. Farmers and processors need to adopt better processing methods to improve the shelf life and marketability of bananas.

Insufficient Hygiene Conditions in the Market: In markets where hygiene standards are not maintained, bananas can become contaminated with dirt, pests, or bacteria, which accelerates spoilage. Proper cleaning and handling in markets are essential to maintaining fruit quality.

6.2 Value Addition and Opportunities

In addition to reducing post-harvest losses, value addition presents significant opportunities for improving the profitability of the banana value chain. Value-added products, such as banana flour, banana chips, juice, and dried banana products, can extend the shelf life of bananas and open new markets both locally and internationally.

6.2.1 Value addition involves processing bananas into various forms that are more shelf-stable and have higher market demand. For example:

Banana Flour: Processed from unripe bananas, banana flour is a gluten-free alternative for baking and is in high demand in the health food market.

Banana Chips: A popular snack, banana chips are made by slicing bananas thinly and frying or dehydrating them.

Banana Juice and Smoothies: Made from ripe bananas, banana juice or smoothies are a popular product in the beverage sector.

Dried Bananas: Sun-dried or mechanically dried bananas can be packaged and sold as snacks or used in other processed food products.

By adopting value addition strategies, farmers and processors can reduce post-harvest losses, increase revenue, and tap into growing consumer markets for processed banana products. The adoption of these technologies and practices is essential for transforming banana production into a more profitable and sustainable industry.

6.3 Critical Loss Points and Recommended Good Agricultural Practices (GAP) for Post-Harvest Management in Banana Production

Post-harvest losses in banana production can occur at various stages of the supply chain, from pre-harvest to final market delivery. Identifying critical loss points and implementing Good Agricultural Practices (GAP) is essential for reducing losses and improving the quality and shelf life of bananas. Below is a summary of key loss points, their causes, and recommended GAPs to mitigate these losses.

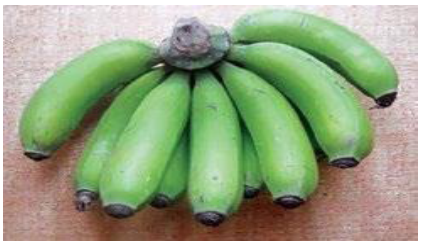
Table

Critical Loss Point	Causes of Losses	Recommended GAP
Pre-Harvest	- Varieties susceptible to diseases and pests	- Use disease- and pest-resistant/tolerant banana varieties to minimize vulnerability.
Harvest	- Not observing proper maturity indices	- Harvest bananas at the right maturity stage for optimal quality and shelf life.
	- Poor weather conditions at harvest (e.g., excessive rain, heat)	- Harvest during the coolest part of the day to reduce the risk of damage and preserve quality.
	- Lack of labor for timely harvesting	- Ensure adequate labor is available for harvesting to avoid delays that affect fruit quality.
	- Improper harvesting methods (e.g., rough handling leading to mechanical injury)	- Harvest carefully to avoid mechanical damage, using proper tools and techniques to prevent bruising.
Pre-Cooling	- Lack of pre-cooling facilities (insufficient cooling to remove field heat)	- Implement pre-cooling immediately after harvest to reduce field heat, preserving freshness and extending shelf life.
		- Ensure that pack-houses are cold, well-ventilated, and equipped with cooling facilities to regulate temperature.
Sorting and Grading	- Inadequate sorting leading to the inclusion of damaged or diseased bananas	- Sort bananas carefully to remove overripe, rotten, damaged, or diseased fruits. Only market healthy, high-quality bananas.
Transportation	- Lack of appropriate transport (e.g., unsuitable vehicles, lack of cooling)	- Use appropriate transport, such as vehicles with cooling systems, to ensure temperature control during transit.
	- Rough handling during loading and unloading, leading to physical injury of the fruits	- Handle bananas gently during loading, unloading, and transportation to prevent bruising or crushing.
Storage	- Fluctuations in storage temperature and relative humidity (RH), leading to premature ripening or spoilage	- Maintain stable storage conditions with properly functioning temperature and humidity monitors.
	- Presence of pests and diseases in storage areas	- Ensure proper pest control measures are in place to keep the storage environment clean and safe.

Critical Loss Point	Causes of Losses	Recommended GAP
	- Poor food safety and hygiene standards in storage areas	- Maintain high food safety and hygiene standards in storage areas, ensuring clean surfaces and regular sanitation.
Packaging	- Inappropriate packaging containers (e.g., unsuitable materials or insufficient protection)	- Use suitable, safe, and durable packaging materials, such as stackable plastic crates, to protect the fruit during handling and transport.
	- Lack of hygiene and safety in packaging processes	- Pack bananas in the field immediately after harvest to minimize handling. Ensure food safety measures are followed during packaging.

6.3.1 Key Points for Successful Post-Harvest Management

By implementing the recommended Good Agricultural Practices (GAP) at each critical loss point, farmers can reduce the risk of post-harvest losses, ensuring that bananas reach the market in optimal condition. These practices improve not only the quantity of bananas available for sale but also their quality, shelf life, and market value. Proper management at each stage—from pre-harvest selection of resistant varieties to careful harvesting, sorting, and packaging—plays a crucial role in the overall success of banana production.

Harvest Index	Characteristics	Use of Banana	Pictorial
Light three quarters	Sharo Angles are still present	Used for Cooking	
Full three quarters	Fingers are angular in shape	Used for processing and cooking	
Full green	Fingers are well rounded	Processing	

Harvest Index	Characteris-tics	Use of Banana	Pictorial
Full ripe	Yellow bananas	Eaten raw/processing	

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Packaging	- Inappropriate packaging containers (e.g., unsuitable materials or insufficient protection)	- Use suitable, safe, and durable packaging materials, such as stackable plastic crates, to protect the fruit during handling and transport.
	- Lack of hygiene and safety in packaging processes	- Pack bananas in the field immediately after harvest to minimize handling. Ensure food safety measures are followed during packaging.

6.5 Key Points for Successful Post-Harvest Management

Effective post-harvest management is essential for minimizing losses and improving the overall quality of bananas. By following the recommended GAPs at each critical loss point, farmers can:

Reduce Post-Harvest Losses: Proper handling, sorting, and packaging reduce the chances of physical damage, spoilage, and disease contamination.

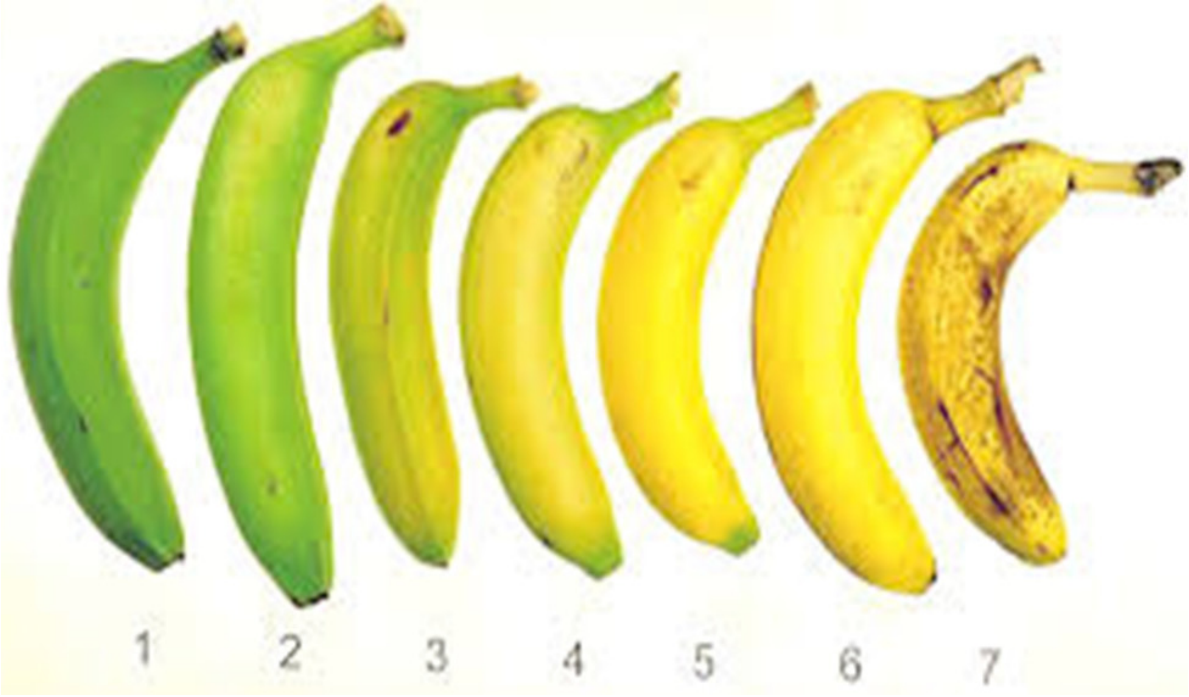
Maintain Fruit Quality: Implementing practices like timely harvesting, pre-cooling, and proper storage conditions helps preserve the fruit's freshness, nutritional value, and appearance.

Extend Shelf Life: Effective temperature and humidity control throughout the post-harvest process, along with proper transportation, storage, and packaging, ensures that bananas reach the market in good condition.

Enhance Marketability: Bananas with minimal damage, optimal ripeness, and excellent visual quality are more likely to fetch higher prices, both locally and internationally.

By paying close attention to these critical loss points and adopting GAPs, banana farmers can improve their productivity, reduce waste, and increase their market competitiveness. Effective post-harvest management not only enhances the profitability of banana farming but also contributes to food security and sustainability in the banana value chain.

VISUAL COLOUR CHANGE



Source: KALRO TIMPS 2022

6.5.1 Harvesting of Mature Fruits

Mature fruits have a distinctive flavor, a crisp texture, and a pale green color. Their sugar content (TSS) ranges from 15-25° Brix. Harvesting typically begins 80 to 180 days after full bloom, which is approximately 10 to 18 months after planting.

6.5.2 Importance of Harvesting

Harvesting is the first step in the postharvest life of horticultural crops. It is a critical operation that directly influences the final quality of the crop. The quality of the produce includes its nutritional value, freshness, freedom from mechanical damage, and overall flavor.

Early Harvesting:

Leads to lower yields

Results in a higher proportion of immature fruit

Causes poor fruit quality

Can result in uneven ripening or rotting

Delayed Harvesting:

Leads to fruit losses from over-ripening

Increases losses due to damage from insects, rodents, birds, monkeys, and other pests

6.5.3 Precautions During Harvesting

Ensure hands are clean and observe strict hygiene practices to prevent contamination.

Handle fruits carefully to avoid mechanical injuries or bruising.

Protect harvested fruits from direct sunlight by placing them in a shaded area.

Prevent harvested banana bunches from coming into contact with the soil by using banana leaves as a base during handling.

Weighing bananas at field level

Weighing Banana at aggregation Centre (Source: Kisii County Crops Department, 2023)

6.6 Dehanding

Dehanding refers to the process of separating the hands from the banana bunch and removing the stalk. This operation should be carried out with care to maintain fruit quality.

Dehanding should be performed in the field using a sharp, clean knife.

The crown should not be cut too close to the hands to avoid damaging the fingers or breaking the fruit.

Hands should be handled gently to prevent any bruising or injury during the dehanding process.

6.6.1 Dehanding Tools

Dehanding is most effectively carried out with a specialized dehanding knife, which is curved to fit the shape of the banana crown.

Dehanding, dewaxing and cleaning of bananas (Source: Shep 2018)

6.7 Washing and Delatexing

Washing and delatexing are essential postharvest steps to ensure clean, high-quality bananas and to improve their shelf life.

Washing removes dirt and latex from the bananas. Begin by washing the bananas in clean, cool water in a wash tank for 15-20 minutes to remove surface dirt. Prolonged washing should be avoided, as it can cause the bananas to absorb water, which may affect their quality.

After washing, treat the bananas in a solution containing 1% alum for approximately 15 minutes. This helps to remove the latex, which can stain the peel and affect the appearance of the fruit.

Once washed and de-latexed, dry the bananas for a few minutes to remove excess moisture before packing or transporting.

Bananas for sale to hotels, supermarkets, and food service establishments should always be washed, especially if they are not bagged, to ensure cleanliness and improve the product's marketability.

6.8 Sorting

Sorting is a crucial postharvest step that ensures only the best-quality bananas reach the market. The process involves removing undesirable fruits, including:

Broken, immature, and over-mature fruits

Bruised or physically damaged fruits

Discolored fruit

Pest and disease-damaged fruits (e.g., cigar-end rot, insect damage, cracked or mechanically damaged bananas)

Sorting helps improve the overall quality of the batch, ensuring that only the most marketable bananas are selected for further processing or sale.

6.9 Grading

Grading is the process of classifying bananas into different categories based on specific criteria. This step is essential to ensure that bananas meet the industry standards for various markets and uses.

Bananas are typically graded based on the following factors:

Color: Ranges from green (unripe) to yellow (ripe), with a consistent, uniform color being preferred for retail markets.

Size: Bananas are sorted into different size categories depending on the intended market (e.g., small, medium, large).

Weight: Bananas are graded according to their weight, with heavier fruit typically being classified into higher grades.

Maturity stage/ripening: The degree of ripeness (from unripe to fully ripe) is an important factor for grading, especially for export or processing.

At this stage, bananas are also selected for specific uses, such as fresh fruit sales, processing, or export.

Grading and storage areas should be clearly demarcated to avoid cross-contamination between different grades and to maintain a systematic approach to handling the bananas.

Fruits of superior grades fetch higher prices in the market, so careful grading is essential for maximizing the value of the harvest.

6.9 Pre-cooling of Harvested Bananas

Bananas are highly sensitive to temperature changes, and exposure to high temperatures or delays between harvesting and cooling can lead to quality degradation.

Pre-cooling removes field heat and reduces the temperature of fresh bananas before marketing. The benefits of pre-cooling include:

Reducing the loss of **flavor**, **nutritional value**, and **market value**.

Lowering respiration rates, which helps to preserve freshness and extends shelf life.

Slowing down the growth of postharvest rots caused by pests and diseases.

Reducing water loss, which helps prevent **shriveling**.

The **lowest safe storage temperature for bananas** is between **5-10°C**.

Pre-cooling should be done immediately after harvesting (within 1 hour). A delay of just 1 hour can reduce the shelf life of bananas by up to 1 day. Therefore, efficient pre-cooling is crucial for maintaining the quality of the produce during transit and storage.

6.9.1 Available Pre-cooling Options:

Shading after harvest: Protects bananas from direct sun exposure and helps maintain cool temperatures.

Evaporative charcoal cooler: A simple, cost-effective cooling method using the evaporation of water to lower temperatures.

Zero Energy Brick Cooler: A low-cost cooling system that uses bricks and water evaporation to keep temperatures low.

CoolBot™: An advanced cooling system that helps regulate temperature efficiently in controlled storage areas.

Wakati™ technology: A sustainable cooling solution using a low-energy design for preserving fresh produce.

6.10 Packaging

Packaging plays a vital role in protecting bananas from mechanical injury, contamination, and other environmental factors. Proper packaging is key to maintaining product quality and enhancing marketability.

Packaging helps to:

Protect bananas from **physical damage**, **tampering**, and contamination from **biological**, **chemical**, and **physical** sources.

Facilitate the efficient **handling and transportation** of bananas.

Ensure the bananas retain their **freshness**, appearance, and quality during transit.

Improve **market value** by presenting a professional, clean, and attractive product.

However, using unsuitable packaging materials can lead to banana damage, resulting in **losses** and **reduced quality**.

6.10.1 Packaging Materials:

Plastic crates: Commonly used for transporting bananas, offering protection and ventilation.

Wooden crates: Traditionally used for bananas, providing good support but requiring careful handling to avoid splintering.

Plastic containers: Ideal for smaller quantities, providing flexibility and ease of handling.

Cardboard boxes: Lightweight and cost-effective, often used for smaller packages or for bananas sold in retail.

Punnets: Small, open containers used for retail or smaller market outlets.

Proper packaging not only helps preserve banana quality but also boosts **market appeal** and supports easier distribution.

6.11 Transportation

Transportation is a crucial step in ensuring the quality of bananas from the farm to the packhouse and then to the market. It must be carried out with care to minimize damage and maintain the freshness of the produce. There are two main stages of transportation: from the farm to the packhouse and from the packhouse to the market.

Transportation by bicycle

Transportation using trucks

6.11.1 From the Farm to the Packhouse

The primary goal during this stage is to **reduce damage to harvested produce** while ensuring the bananas are transported safely and efficiently.

Use containers that **allow proper ventilation** to maintain airflow and reduce the risk of heat buildup, which can accelerate ripening or damage the bananas.

Handle bananas with care, ensuring they are not dropped, thrown, or subjected to rough handling.

Avoid overloading transport vehicles, as excessive weight can cause bruising and other physical damage.

Stack bananas carefully: Bananas at the bottom of the transport vehicle should not be used as steps to allow stacking to a greater height. This prevents excessive pressure on the lower layers of fruit.

6.11.2 From the Packhouse to the Market

For the final stage of transportation, the objective is to **keep the bananas as cool as possible** and maintain their freshness until they reach the market.

Load the bananas under shade to protect them from direct sunlight, which can lead to heat stress and a reduction in quality.

Cover the back of trucks with canvas to provide shade and protect the bananas from exposure to sunlight. Make sure the cover allows for air circulation. Light-colored materials are preferred, as they help **reflect heat** and reduce temperature buildup.

Use containers that **allow ventilation** to ensure good airflow around the bananas during transport, helping to preserve their freshness and prevent premature ripening.

6.11.3 Post-Harvest Diseases

After harvesting, bananas are vulnerable to a range of diseases that can affect their quality, shelf life, and marketability. These diseases are typically caused by fungi, bacteria, or other pathogens that can thrive under improper handling, storage, and environmental conditions. Proper post-harvest care is essential to prevent and manage these diseases, ensuring that the fruit remains safe, nutritious, and attractive to consumers.

Fungal Diseases

Bananas are particularly susceptible to fungal diseases during post-harvest handling. Key fungal diseases include:

Anthracnose: A common fungal disease that causes dark, sunken lesions on the peel and can lead to premature ripening and rot.

Crown Rot: A fungal infection that typically affects the crown of the banana bunch, causing rapid decay and significant post-harvest loss.

Cigar End Rot: A disease that causes blackened tips of the banana fruit, making it unattractive for sale and lowering its market value.

Control of Post-Harvest Diseases

Effective management of post-harvest diseases relies on a combination of **preventive measures** and **careful handling**. Key strategies include:

Careful handling of fruit: Minimize physical damage during harvesting, sorting, and packing to prevent openings through which pathogens can enter.

Appropriate sorting and grading: Remove damaged or diseased bananas during sorting to prevent the spread of infections to healthy fruit.

Temperature control: Storing bananas at **10°C** slows down the rate of disease development, compared to ambient temperature storage. Immediate post-harvest cooling is crucial to reducing disease risk.

Minimizing bruising: Bruising creates entry points for pathogens and accelerates the spread of infections. Handle bananas gently and avoid rough transport or stacking.

Field sanitation: Proper field hygiene, including the removal of infected plant material, helps prevent the spread of diseases from the field to the post-harvest handling process.

By adopting these practices, banana growers and handlers can significantly reduce the incidence of post-harvest diseases, improving both the **shelf life** and **marketability** of their fruit.

6.12 Banana Value Addition

Value addition refers to the transformation of raw bananas into a variety of processed products that have enhanced value, longer shelf life, and greater consumer appeal. This process not only increases the economic return on banana production but also provides a way to make use of surplus or less marketable bananas that may otherwise go to waste.

Value addition is a critical strategy for improving the sustainability and profitability of banana farming, particularly in regions where bananas are produced in large quantities. By processing bananas into a range of products, farmers can tap into new markets and reduce post-harvest losses.

6.12.1 Importance of Value Addition

The value addition process brings several significant benefits, both for producers and consumers:

Product Diversification: Creating a variety of banana-based products opens new avenues for sales and consumption. This includes fresh and processed products that appeal to different consumer preferences.

Market Diversification: By offering value-added banana products, producers can access new markets, including local and international markets, further expanding their reach.

Enhancing Food Safety: Processing bananas can remove potential hazards, such as contaminants or pathogens, thereby improving food safety.

Food Preservation: Value-added products like banana flour, wine, and dried snacks have a longer shelf life, helping to preserve bananas that would otherwise spoil.

Reducing Post-Harvest Losses: Processing helps reduce losses that occur from overripe or damaged bananas that are no longer suitable for fresh fruit markets.

Reduced Bulk for Transportation and Storage: Processed products, such as banana flour or dried banana chips, are lighter and less bulky, making them easier to transport and store compared to fresh bananas.

Improved Food Quality and Consumer Acceptability: Value-added products can be enhanced in flavor, texture, and packaging, making them more attractive to consumers.

Utilization of Surplus or Unmarketable Produce: Bananas that are unsuitable for sale as fresh produce, due to over-ripening, blemishes, or other imperfections, can be processed into value-added products, reducing waste.

Economic Opportunities: Value addition creates employment opportunities in rural areas, including roles in processing, packaging, marketing, and distribution.

6.12.2 Banana Value-Added Products

There are numerous ways to process bananas into value-added products, including:

Ripened Bananas: Naturally ripened bananas, which are sold as fresh fruit or used in further processing.

Banana Flour: Made by drying and grinding bananas, it is a versatile ingredient for baking, cooking, and gluten-free products.

Banana Crisps: Thinly sliced bananas fried or baked to create a crunchy, snackable product.

Banana Wine: A fermented alcoholic beverage made from ripe bananas, popular in some regions.

Banana Juice: A refreshing beverage made from mashed bananas, often blended with other fruits or sweeteners.

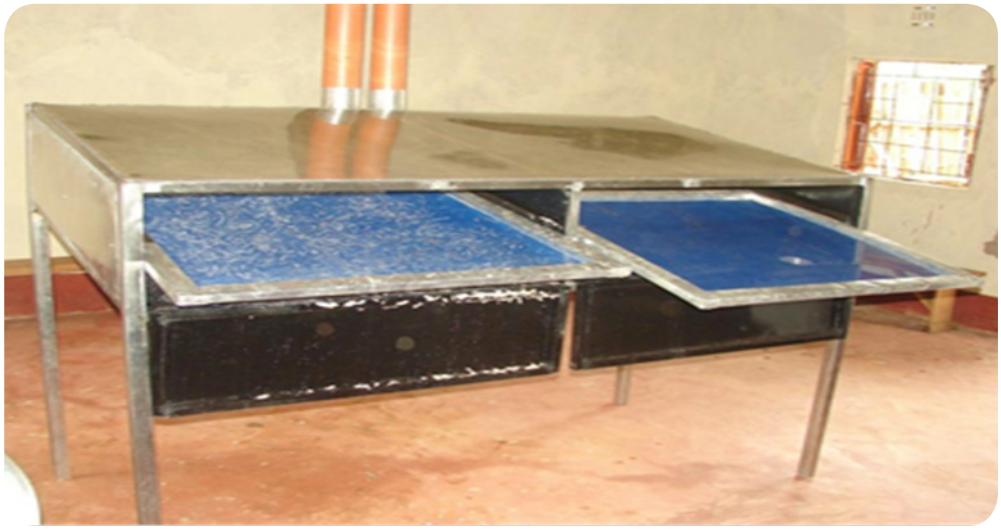
Banana Puree: A smooth, processed product made from ripe bananas, used in baby foods, baked goods, or as a flavoring agent.

Banana Jam and Jellies: A sweet spread made from cooked bananas, sugar, and pectin.

Fried Banana Products: Various fried banana snacks, including fritters, chips, and other fried goods.

By diversifying into these value-added products, producers can enhance the profitability and sustainability of their banana crops, while meeting the growing consumer demand for innovative and convenient food products.

A range of Value added products of banana: Source KALRO 2022



Banana Solar drier

Dehydrated bananas

6.12.3 Banana Flour from Unripe Bananas

Banana flour is a versatile, gluten-free product made from unripe bananas. It has gained popularity as a nutritious alternative to traditional flour in various culinary applications. The process of making

banana flour involves several key steps that ensure the final product retains its nutritional value while being easy to store and use.

Preparation and Processing of Banana Flour

Selection and Cleaning: Begin by selecting firm, unripe bananas. Peel and slice the bananas to facilitate the drying process. Ensure that all fruits are clean and free from contaminants before proceeding.

Treatment with Sodium Benzoate: To prevent browning and preserve the fruit, treat the banana slices with a solution of **sodium benzoate** for **10 minutes**. This step also helps maintain the quality of the flour by reducing the potential for microbial contamination during drying.

Drying: Dry the banana slices in a **solar dryer** until they reach a moisture content of **12%** or lower. This typically takes **less than 48 hours**, depending on the drying conditions and ambient temperature. Solar drying is an energy-efficient method that preserves the natural nutrients and flavor of the bananas.

Milling: Once the banana slices are thoroughly dried, they are milled into a fine powder using a **conventional hammer mill**. The milling process should be done carefully to avoid overheating, which can degrade the quality of the flour.

Packaging: After milling, the banana flour is packed into airtight containers to preserve freshness and prevent moisture absorption. Proper packaging ensures that the flour retains its quality during storage and transport.

6.12.4 Nutritional Benefits of Banana Flour

Banana flour is an excellent source of essential nutrients, making it a valuable addition to any diet. Its nutritional profile includes:

Carbohydrates: Banana flour is primarily composed of carbohydrates, making up **74-78% by weight**. This makes it a good source of energy, especially for individuals who follow a gluten-free or plant-based diet.

Minerals: Banana flour is rich in important minerals, including:

Potassium: **6,000-10,000 mg/kg**. Potassium is crucial for maintaining heart health and balancing electrolytes in the body.

Iron: **15-20 mg/kg**. Iron is essential for the production of red blood cells and the prevention of anemia.

Calcium: **8.9-10.2 mg/kg**. Calcium is vital for bone health and muscular function.

Protein: Banana flour contains **5.8-6.5% protein**, which is comparable to the protein content found in many cereals. This makes banana flour a good source of plant-based protein, particularly for those on vegetarian or vegan diets.

Low Reducing Sugars: The levels of **reducing sugars** (simple sugars) in banana flour are **low**, making it a suitable option for diabetics or individuals looking to manage their blood sugar levels.

6.12.5 Health Benefits and Functional Uses

Banana flour retains many of the beneficial nutrients found in fresh bananas, such as **high levels of potassium** and **iron**, both of which are essential for good health. These minerals are not significantly

reduced during the processing of banana flour, ensuring that the final product remains a nutrient-dense food source.

Additionally, banana flour is **gluten-free**, making it an excellent alternative for individuals with gluten sensitivity or celiac disease. It is also **high in dietary fiber**, which promotes healthy digestion and may help manage cholesterol levels.

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6.13 Banana Peel: Nutritional Value and Value-Added Products

The banana peel, often discarded, is actually a **nutrient-dense** part of the fruit, offering a wealth of **vitamins**, **minerals**, and **antioxidants**. Consuming or processing banana peel can provide various health benefits, making it an excellent addition to the food chain, especially in the context of sustainable and nutritious food options.

Rich in **potassium**, **iron**, **calcium**, and **vitamin C**, banana peel is also packed with **dietary fiber** and antioxidants, which help **neutralize free radicals** and reduce oxidative stress—key factors in maintaining overall health and preventing chronic diseases.

6.13.1 Products Made from Banana Peel

Given its nutritional benefits and versatility, banana peel can be processed into a wide variety of value-added products. These products not only make use of what would otherwise be waste but also offer innovative, healthy options for consumers. Some of the popular products made from banana peel include:

Instant Soup: Dried and ground banana peel can be incorporated into soup powders, combined with vegetables and spices to create a flavorful, nutritious instant soup mix. The fiber, antioxidants, and minerals from the peel make this a health-boosting, easy-to-prepare meal.

Sauce: Banana peel can be cooked and blended into a savory sauce, often used as a topping or dip. By combining the peel with other ingredients like tomatoes, garlic, and herbs, this sauce delivers added nutrients and flavor, while enhancing the fiber content of meals.

Chutney: Banana peel can be finely chopped and cooked with spices, vinegar, and sugar to make a **flavorful chutney**. This tangy condiment adds a nutritious boost to meals while helping reduce food waste.

Fruit Smoothie: The banana peel can be blended into smoothies, adding both texture and nutritional value. When combined with fresh fruits like mango, berries, or pineapple, banana peel enhances the fiber and antioxidant content of the smoothie, making it a nutritious and eco-friendly drink option.

Ready-to-Drink Curry Mix: Another innovative product made from banana peel is a **ready-to-drink curry mix**. The peel is cooked and blended into a smooth paste, often spiced with traditional curry ingredients like cumin, turmeric, and coriander, to create a pre-made curry mix that is easy to prepare and rich in flavor.

These value-added banana peel products help reduce food waste and support **sustainability** by utilizing the entire banana, from peel to pulp. They also offer **health-conscious alternatives** to more conventional products, making banana peel a valuable resource in both local and international markets.

6.13.2 Benefits of Banana Peel Value Addition

The processing of banana peel into food products offers a variety of benefits:

Sustainable Use of Resources: By incorporating the peel into food products, waste is minimized, and the environmental footprint of banana production is reduced.

Nutritional Enhancement: Banana peel is a good source of **fiber**, **potassium**, **iron**, **calcium**, and **vitamins**, which can enrich the nutritional profile of various foods.

New Market Opportunities: Value-added banana peel products can open up new markets, particularly in the growing **health-conscious food sector**, where consumers seek nutrient-dense and sustainable options.

By transforming banana peel into these innovative products, producers not only reduce food waste but also offer consumers affordable, nutritious, and eco-friendly alternatives to traditional processed foods

Banana Flower

6.14 Banana Flower: Nutritional Value and Value-Added Products

The **banana flower**, also known as the **banana blossom**, is a highly nutritious part of the banana plant that is often overlooked. It is rich in essential **fiber**, **minerals**, and **vitamins**, making it a valuable addition to the diet. The banana flower has been used for centuries in many tropical regions for its health benefits and versatility in cooking.

Packed with **dietary fiber**, **potassium**, **iron**, and **vitamin C**, the banana flower also contains **antioxidants** that help combat oxidative stress and support overall health. It is particularly beneficial for digestive health due to its high fiber content, and it has been traditionally used to address issues such as **anemia** and **blood sugar regulation**.

6.14.1 Products Made from Banana Flower

The banana flower can be used in a variety of dishes, offering both nutritional and culinary benefits. Its mild flavor and unique texture make it a versatile ingredient in cooking. Some common products made from banana flower include:

Banana Flower Salad: The banana flower can be sliced thinly and combined with fresh herbs, vegetables, and a tangy dressing to create a nutritious and refreshing salad. It is often used in Southeast Asian and Indian cuisines, where it is prized for its high fiber content and health benefits.

Banana Flower Soup: The banana flower can be used as a base for soups and stews. It is commonly cooked with spices, vegetables, and broth to create a hearty, nutritious soup. Rich in fiber, antioxidants, and vitamins, this soup offers a great way to incorporate the health benefits of the banana flower into the diet.

These value-added banana flower products not only help reduce food waste but also promote **healthy eating** by incorporating a nutrient-rich ingredient into everyday meals.

6.14.3 Health Benefits of Banana Flower

In addition to being a versatile food ingredient, banana flower offers a range of health benefits:

Digestive Health: The high fiber content of banana flower aids in digestion and promotes gut health, helping to prevent constipation and regulate bowel movements.

Blood Sugar Regulation: Banana flower has been traditionally used in some cultures to help manage blood sugar levels, making it beneficial for people with **diabetes** or those looking to control their blood sugar.

Rich in Minerals and Vitamins: Banana flower is an excellent source of **potassium**, **iron**, and **vitamin C**, which help support **heart health**, **immune function**, and the prevention of **iron-deficiency anemia**.

Antioxidant Properties: Packed with **antioxidants**, banana flower helps to neutralize free radicals, protecting the body from oxidative stress and inflammation.

By incorporating banana flower into various food products, producers can offer **nutritious** and **sustainable** food options that appeal to health-conscious consumers, while also reducing waste and making full use of the banana plant.

6.14.4 Banana Artefacts: Uses of Banana Fiber

Banana fiber, derived from the pseudostems of the banana plant, is a **natural, eco-friendly material** that has been used for centuries in various cultures. Known for its **strength**, **durability**, and **versatility**, banana fiber has a wide range of applications, particularly in the creation of sustainable, handmade products. This biodegradable material is not only valuable in **traditional crafts**, but also increasingly sought after in **modern industries** looking for **sustainable alternatives** to synthetic fibers.

6.14.5 Uses of Banana Fiber

Banana fiber is extracted from the pseudostems of the banana plant, which are often considered agricultural waste. The fibers are strong and flexible, making them ideal for a variety of uses, including:

Handcrafted Products: Banana fiber is widely used in the creation of **handcrafted items** such as mats, textiles, and decorative goods. Its natural texture and strength make it ideal for weaving into intricate patterns and designs. Items like **bags**, **clothing**, and **home decor** products are often made from banana fiber, offering both **aesthetic appeal** and **eco-friendly sustainability**.

Rope Making: Banana fiber is strong enough to be used for producing **ropes** and **twine**. These ropes are typically used in farming, construction, and even as **marine ropes** due to their durability and resistance to wear. In some regions, banana fiber ropes are an essential part of local livelihoods and industries.

Packaging Material: As a sustainable alternative to plastic, banana fiber is increasingly being used to create **biodegradable packaging materials**. These materials are lightweight yet strong, making them suitable for packaging a variety of products, from food to industrial goods. The use of banana fiber for packaging helps reduce environmental impact by providing an **eco-friendly option** for manufacturers and consumers alike.

6.14.6 Benefits of Using Banana Fiber

The use of banana fiber is highly beneficial, both from an environmental and economic standpoint:

Sustainability: Banana fiber is **biodegradable**, **renewable**, and requires fewer resources to produce compared to synthetic fibers. This makes it an environmentally friendly choice, helping to reduce the demand for non-biodegradable plastics and synthetic materials.

Durability: Despite its natural origin, banana fiber is remarkably **strong** and **durable**. It has a long lifespan, particularly in products like ropes and packaging, where strength is crucial.

Low Environmental Impact: The process of extracting banana fiber from the pseudostems

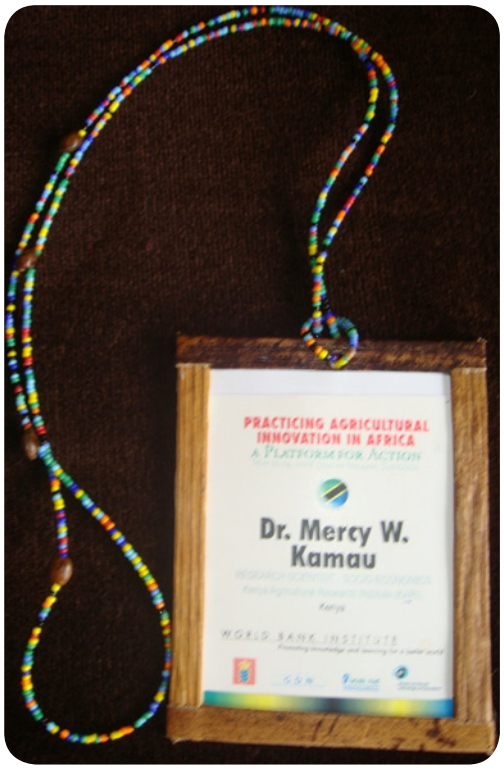
involves minimal processing, and no harmful chemicals are used in the production of the fiber. This makes it a **low-impact** and **sustainable material** compared to many other fibers.

Economic Value: In many regions, banana fiber production provides **additional income** for farmers and artisans. By using the otherwise discarded pseudostems for fiber extraction, banana-growing communities can add value to their crops and create employment opportunities.

6.14.7 Conclusion: Unlocking the Potential of Banana Fiber

Banana fiber represents a **sustainable**, **durable**, and **eco-friendly** alternative to synthetic fibers and materials. By transforming banana plant waste into valuable products, banana fiber helps reduce **waste**, provides **economic opportunities**, and offers **biodegradable solutions** to industries ranging from **textiles** to **packaging**.

As the world moves toward more **sustainable practices** and **circular economies**, banana fiber stands out as a **natural resource** that offers a wide range of possibilities. Embracing banana.



Banana Artefacts (Source: Hope For Tomorrow CBO)

Banana fiber, derived from the **pseudostem** of the banana plant, is a **strong, durable, and eco-friendly material** that has been used for centuries in various cultures, especially in tropical regions. The fibers are extracted from the banana plant's stem, which is typically discarded after fruit harvest, making banana fiber a valuable **by-product** that helps minimize waste and adds economic value to banana farming.

The use of banana fiber is increasingly popular in the context of **sustainability** and **eco-conscious production**. As the demand for **biodegradable** and **natural materials** grows, banana fiber is seen as a viable and **environmentally-friendly** alternative to synthetic fibers like polyester and nylon. Its **strength**, **flexibility**, and **biodegradability** make it suitable for a wide range of applications, both traditional and modern.

6.15 Food Safety in the Banana Value Chain

Food safety is a critical consideration at every stage of the banana value chain. Ensuring the safety and quality of bananas from the farm to the market involves attention to hygiene, proper handling, and adherence to safety standards throughout the production, processing, and distribution phases. This section outlines the key food safety measures that should be implemented in banana production, focusing on input supply, site selection, planting, orchard management, harvesting, postharvest handling, value addition, transportation, packaging, and labeling. It also highlights the importance of hazard analysis, standard operating procedures (SOPs), and organic certification.

6.15.1 Input Supply: Ensuring Safe Inputs

The safety of bananas starts with the quality of inputs used in their production. Use of contaminated or substandard inputs, such as pesticides, fertilizers, and planting materials, can introduce harmful chemicals or pathogens into the fruit. To ensure food safety at this stage:

Certified Inputs: Use certified and recommended inputs for fertilizers, pesticides, herbicides, and other chemicals. Always follow guidelines for safe application to prevent chemical residues on harvested bananas.

Clean Planting Material: Ensure that planting materials (suckers or tissue culture plants) are sourced from certified nurseries. Suckers should be disease-free and not carry pests that could spread to the orchard.

Record Keeping: Maintain records of input sources and usage to trace the origins of any potential contamination issues.

6.15.2. Site Selection and Preparation

Choosing an appropriate site for banana cultivation is critical to minimizing risks to food safety. Key considerations for site selection include:

Soil Health: Test soil quality for nutrient content and potential contaminants (e.g., heavy metals, pathogens). Ensure the soil is free from chemicals that could affect fruit safety.

Water Supply: Ensure that water used for irrigation is clean and free from contaminants such as pathogens, heavy metals, or chemical residues. Water used for washing bananas after harvest should be potable or sourced from clean, treated sources.

Proximity to Pollution: Avoid planting bananas near sources of pollution such as factories, waste dumps, or industrial areas that could contaminate the crops.

6.15.3. Planting: Safe Practices for Growth

When planting bananas, proper care should be taken to maintain food safety and avoid contamination:

Hygiene: Ensure that all tools used in planting (e.g., knives, spades) are sanitized to avoid cross-contamination.

Spacing and Care: Proper spacing between plants ensures good airflow, reducing the risk of mold or fungal contamination, which could affect fruit safety.

Use of Pesticides and Herbicides: Only apply approved pesticides and herbicides, and ensure they are used in accordance with recommended safety guidelines to prevent residues on the fruit.

6.15.4. Water Quality: Critical for Food Safety

Water plays a significant role in food safety throughout the banana value chain, from irrigation to postharvest washing:

Irrigation Water: Ensure irrigation water is of safe quality, free from contaminants such as pathogens, harmful microorganisms, and toxic substances. Regularly test water sources to verify their safety.

Postharvest Washing: During postharvest handling, bananas should be washed in clean water to remove dirt and latex. If a solution is used for latex removal, ensure that it is food-grade and non-toxic.

6.15.5. Orchard Management: Ensuring Safe Growing Practices

Ongoing orchard management practices are critical in ensuring food safety:

Pest and Disease Control: Use integrated pest management (IPM) strategies to minimize the use of chemical pesticides and reduce pesticide residues on bananas. Where chemical treatments are necessary, ensure proper waiting periods before harvest.

Fertilizer Management: Use fertilizers in accordance with recommended guidelines to avoid over-fertilization, which can lead to chemical residues on the fruit.

Monitoring: Regularly monitor plants for signs of pest infestations, disease outbreaks, or nutrient deficiencies that may affect the safety and quality of the fruit.

6.15.6. Harvesting: Safe Handling of Bananas

Harvesting bananas requires attention to food safety to minimize the risk of contamination and injury to the fruit:

Standard Operating Procedures (SOPs): Develop and implement SOPs for safe and hygienic harvesting. These should include guidelines for:

Using clean, sanitized tools for cutting banana bunches.

Avoiding mechanical injury to the fruit to reduce the risk of spoilage and pathogen entry.

Handling fruit gently to avoid bruising or contamination.

Worker Hygiene: Ensure that workers handling bananas during harvest maintain good personal hygiene, including handwashing, and wear appropriate protective clothing to avoid contaminating the fruit.

6.15.7 Postharvest Management: Minimizing Food Safety Risks

Postharvest handling practices are crucial for maintaining food safety and quality. Key food safety measures include:

Sorting and Grading: Immediately after harvest, bananas should be sorted to remove any damaged or diseased fruit that could pose a food safety risk.

Washing and De-latexing: Bananas should be washed in clean water to remove dirt and latex. If using a chemical solution for latex removal (such as alum), ensure it is food-grade and used within safe concentrations.

Storage Conditions: Store bananas in appropriate conditions to prevent contamination. Maintain optimal temperatures (5-10°C) and humidity to prevent mold growth and spoilage.

Packaging: Use clean, food-grade packaging materials for bananas. Packaging should be designed to prevent contamination and physical damage.

6.15.8 Hazard Analysis and Critical Control Points (HACCP)

Implementing a Hazard Analysis and Critical Control Point (HACCP) system is an essential step in ensuring food safety throughout the banana value chain. This system helps to identify potential food safety hazards at every stage of production and postharvest handling, and puts control measures in place to mitigate these risks. Critical control points may include:

Water Quality: Regular testing and control of water used in irrigation and postharvest handling.

Pesticide Residues: Monitoring pesticide usage and ensuring compliance with safe residue limits.

Temperature Control: Ensuring bananas are stored at optimal temperatures to prevent microbial growth and spoilage.

6.15.9 Value Addition: Safe Processing Practices

Value-added banana products, such as banana flour, banana crisps, and banana wine, should be produced under strict food safety standards to ensure they are safe for consumption:

Food Safety Standards: Follow Good Manufacturing Practices (GMP) and Hazard Analysis Critical Control Points (HACCP) for processing banana products.

Cleanliness and Hygiene: Ensure that processing facilities are clean, and workers practice proper hygiene to avoid contamination during the value addition process.

Labeling: Properly label all processed banana products with ingredients, production date, expiration date, storage instructions, and certification logos (e.g., organic certification) to inform consumers about the safety and quality of the product.

6.15.10 Transportation: Safe Movement of Bananas

Transportation is a critical part of the banana value chain and requires careful attention to food safety:

Vehicle Hygiene: Ensure that transport vehicles are clean and suitable for carrying fresh produce. Avoid transporting bananas with other products that may contaminate the fruit.

Temperature Control: Use refrigerated vehicles or other temperature-controlled methods for transporting bananas to maintain their freshness and prevent spoilage.

Packaging: Use food-grade packaging materials that protect bananas from contamination during transit and ensure adequate ventilation.

6.15.11 Packaging and Labeling: Ensuring Safety and Transparency

Packaging plays a key role in ensuring the safety and quality of bananas as they move through the value chain:

Safe Packaging Materials: Use food-safe, non-toxic packaging materials such as plastic crates, cardboard boxes, or mesh bags. Packaging should protect bananas from contamination, bruising, and mechanical damage.

Labeling: Clearly label bananas with information on the origin, production method (e.g., organic), best-before date, and storage instructions. Labels should also indicate any relevant food safety certifications.

6.15.12 Organic Certification: Ensuring Compliance with Food Safety Standards

For organic banana production, adherence to organic certification standards ensures that bananas are produced using environmentally friendly methods without synthetic chemicals. This certification process involves:

Certification Bodies: Bananas should be certified by recognized organic certification bodies that verify compliance with organic farming standards.

Traceability: Maintain traceability records to document the entire production process, from planting to harvesting and postharvest handling, ensuring that the product meets organic standards.

6.15.13 Conclusion

Food safety in the banana value chain is a shared responsibility across all stages of production, from farm to table. By adhering to proper food safety standards, such as using certified inputs, managing irrigation water quality, maintaining clean and hygienic practices in orchard management, and ensuring safe postharvest handling, the banana industry can provide high-quality, safe bananas to consumers. Additionally, the implementation of HACCP systems, standard operating procedures, and organic certification helps to ensure that bananas meet food safety standards and consumer expectations for quality and safety.

CHAPTER 7: BUSINESS OPPORTUNITIES AND MARKETING IN THE BANANA VALUE CHAIN

The banana value chain offers significant business opportunities, ranging from production and processing to marketing and distribution. As an increasingly important crop in global agriculture, bananas present diverse avenues for entrepreneurs, smallholders, and large-scale businesses to capitalize on their value-added products and services. This chapter explores the various business opportunities in the banana industry, along with key considerations for successful marketing strategies, particularly in regions where bananas are grown as a staple crop.

7.1 Business Opportunity

A business opportunity exists when sellers of goods and services interact with buyers in a manner that allows for profit generation. These opportunities can either be existing and already being practiced or potential opportunities that remain untapped and are yet to be explored. In the banana value chain, business opportunities exist across various nodes, such as input supply, production, processing, and marketing. These opportunities are influenced by factors such as geography, time, and market demand, and can be shaped by economic, social, and technological changes in the industry.

The banana industry provides a robust platform for business development due to its expansion potential, growing consumer demand, and diverse product options (such as fresh bananas, processed goods, and by-products). The challenge lies in leveraging these opportunities effectively, which requires careful planning, market analysis, and identifying the right value chain segments to target.

7.2 Factors to Consider / Types of Business Opportunities

There are several key factors that influence the identification and success of business opportunities in the banana industry. These factors include:

Competition: The banana market is competitive, with many producers and players in the value chain. However, bananas' diverse attributes (including flavor, ripening rates, and nutritional content) provide room for differentiation and innovation in the marketplace.

Potential for Expansion and Growth: The banana sector offers substantial growth potential, particularly in **emerging markets** where consumer demand for bananas is rising. This is driven by the crop's **low-cost production**, **nutritional value**, and year-round availability.

Emerging Markets: With a growing global population and changing dietary habits, there is increasing demand for bananas in both local and international markets. The rising popularity of processed banana products such as **banana flour**, **banana crisps**, and **banana wine** has opened up **new markets** for value-added products.

Strategic Alliances: There are significant opportunities for **strategic alliances** and partnerships in the banana value chain. Collaborations between **farmers**, **processors**, **distributors**, and **retailers** can help streamline operations, enhance product quality, and increase market access.

Growing Population and Demand: A growing population translates into increasing demand for **food products**, including bananas. As the global demand for fresh fruit and processed banana products rises, businesses can capitalize on this trend by offering innovative products and tapping into niche markets.

Changing Consumer Trends: As consumers become more health-conscious, demand is shifting towards **organic**, **sustainable**, and **processed banana products**. This includes products such as **banana juice**, **banana puree**, and **gluten-free banana flour**.

Technological Advancements: The **internet** and **online marketing** provide opportunities for businesses to reach broader audiences, particularly in the e-commerce space. Online platforms can also facilitate **direct-to-consumer sales** and **marketing**, enhancing customer engagement.

Financial Enablers and Knowledge Access: Availability of **financial resources** (e.g., microfinance, rural finance institutions) and access to **knowledge hubs** (business planning resources, extension services) are crucial for farmers and entrepreneurs to effectively enter and expand within the banana value chain.

7.3 Agribusiness Opportunities in Banana

The banana value chain is multifaceted, and opportunities are available at every step, from **input supply** to **processing** and **marketing**. Some of the key business opportunities include:

Input Supply:

Tissue culture laboratories for the production of disease-free banana planting material.

Hardening nurseries for acclimatizing tissue-cultured banana plants before field planting.

Production:

Increasing **acreage** of banana farms, driven by rising market demand for both fresh and processed bananas.

Aggregation and Supply:

Establishing **aggregation centers** to collect bananas from multiple smallholder farms, ensuring uniform quality and sufficient volumes for processing or large-scale distribution.

Transportation and Logistics:

Developing **logistics** systems to transport bananas efficiently, given the fruit's **perishable nature** and need for **cooling** during transit.

Storage and Preservation:

Investment in **cold storage** and **postharvest technology** to preserve the freshness of bananas and reduce postharvest losses.

Market Facilities:

Developing **marketplaces** and **distribution channels** to connect farmers directly with consumers, retailers, and processors.

Processing and Value Addition:

Investing in **value-added banana products**, such as **banana crisps**, **banana flour**, **banana wine**, **banana jam**, and **artefacts**.

7.4 Banana Marketing

Effective marketing of bananas and their products is essential to ensuring that they reach the right consumers at the right time. However, banana marketing remains underdeveloped in many regions, with middlemen and brokers often exploiting farmers, especially in areas where there is little market organization.

7.4.1 Strengths in Banana Marketing

High Demand: Bananas are one of the most widely consumed fruits globally. They have a short maturity period, allowing for consistent supply to meet growing demand.

Commercial Viability: Bananas are grown in large quantities and sold widely in towns and cities across Kenya, making them a highly commercialized crop.

7.4.2 Weaknesses and Threats in Banana Marketing

Low Yields: Suboptimal farming practices, pest infestations, and poor access to inputs can result in low yields, limiting market supply.

Price Variability: Banana prices can fluctuate depending on local supply, weather conditions, and competition from imports.

Postharvest Losses: Given that bananas are a **perishable** crop, they are prone to **postharvest losses** if not handled and transported correctly.

7.5 Group/Collective Marketing

A highly effective method for banana farmers to enter markets and compete more effectively is through **group or collective marketing**. By pooling their resources, farmers can leverage economies of scale and ensure better access to markets, transportation, and storage facilities.

7.5.1 Advantages of Group Marketing:

Bargaining Power: Groups can negotiate better prices and terms with buyers.

Shared Resources: Pooling resources for transportation, storage, and marketing campaigns can reduce individual costs.

Access to Large Buyers: Group marketing can open doors to large-scale buyers such as **hotels**, **supermarkets**, and **processors**.

7.6 The Five P's of Marketing for Banana Products

Product: This refers to the banana products offered, including **quality**, **packaging**, and the **appearance** of bananas and their processed forms.

Price: The pricing strategy for bananas and banana products, including **discounts**, **credit terms**, and **price positioning** in the market.

Promotion: Strategies for **promoting banana products**, whether through advertisements, **social media**, or in-store promotions.

Place: The **distribution channels** and locations where bananas and processed products will be sold.

People: The **staff**, **salespeople**, and **customer service** teams that will handle consumer relationships and ensure customer satisfaction.

7.7 Success Factors in Group Marketing

For collective marketing to be successful, certain factors need to be in place:

Commitment and Trust: Farmers must be committed to the group's goals and operate with **transparency** and **integrity**.

Leadership: Effective and **democratic leadership** is essential to guide the group, manage resources, and resolve conflicts.

Product Uniformity: Standardized quality, size, and packaging ensure that the group's bananas meet market expectations.

7.8 Challenges in Collective Marketing

Some of the challenges in collective banana marketing include:

Decision-Making Conflicts: Disagreements on key issues can slow down or hinder group activities.

Inadequate Infrastructure: Poor storage facilities and inaccessible roads can limit the effectiveness of collective marketing efforts.

Capital Constraints: Heavy investments may be required for **storage facilities**, **transportation**, and **marketing**.

7.9 Contract Farming and Marketing

Contract farming allows farmers to enter into **agreements** with processors or marketers to produce and supply bananas under set terms. These contracts can provide **guaranteed markets** and **price stability**, offering protection against price volatility and market uncertainty.

7.10 Electronic Marketing (E-Marketing)

With the rise of digital technologies, **e-marketing** is becoming an essential tool in the banana value chain. By leveraging online platforms such as **social media**, **websites**, and **e-commerce**, banana producers and marketers can reach a wider audience, reduce transaction costs, and increase sales opportunities.

7.11 Conclusion

The banana value chain offers a multitude of business opportunities for entrepreneurs, farmers, and businesses across the production, processing, and marketing sectors. By leveraging **collective marketing**, exploring **e-marketing strategies**, and focusing on **quality improvement** and **value addition**, stakeholders in the banana industry can enhance their profitability, overcome challenges, and tap into **emerging markets** for sustainable growth.

7.12 Prices of Banana

Size of bunches Kgs		Cooking type (price per bunch)	Ripening type-Green (price per bunch)	Ripened banana
Large bunches	50-70 kg	500-700	600-900	1,200-1,800
Medium bunches	30-40 kgs	250-350	400 -500	800-1,000
Small bunches	Below 30 kgs	150-200	200 -300	500-600

Source: Kisii County 2023

7.13 Table: Banana Production Financial Summary

Spacing: 3 x 3 Meters

Plant Population: 450 Plants per Acre

Optimal Production Period: 6 Years

Production Years	Establish-ment	Year 1	Year 2	Year 3	Year 4	Year 5
Expected Returns						
Yield (Number of Bunches)	-	450	900	1,350	1,350	1,350
Farm Gate Price per Bunch (Ksh)	-	300	400	400	450	500
Expected Gross Income (Ksh)	-	135,000	360,000	540,000	607,500	675,000
Variable Costs						
Establishment Costs						
Ploughing	3,500	-	-	-	-	-
Planting Suckers (450 @ Ksh 120)	54,000	-	-	-	-	-
Transportation of Suckers (Pick-Up Hire)	4,000	4,000	-	-	-	-
Digging of Holes (450 @ Ksh 25)	11,250	-	-	-	-	-
Manure (1 Debe per Hole @ Ksh 20)	9,000	-	-	-	-	-

Production Years	Establish-ment	Year 1	Year 2	Year 3	Year 4	Year 5
Transportation of Manure (450 Debes @ Ksh 5)	2,250	-	-	-	-	-
Nematicide (1 Tablespoon per Hole)	1,500	-	-	-	-	-
NPK Fertilizer (250 gms per Hole; 3 Bags @ Ksh 3,000)	9,000	-	-	-	-	-
Planting Labour (20 Mandays @ Ksh 150)	3,000	-	-	-	-	-
Transportation of Fertilizers	1,500	-	-	-	-	-
Total Establishment Costs	99,000	-	-	-	-	-
Maintenance Costs						
Weeding (3 Times per Year; 20 Mandays per Year @ Ksh 150)	6,000	6,000	6,000	6,000	6,000	6,000
Propping Poles (Props)	-	22,500	22,500	45,000	45,000	45,000
CAN for Top Dressing (Twice @ Ksh 3,000)	9,000	9,000	9,000	9,000	9,000	9,000
Total Maintenance Costs	15,000	37,500	37,500	60,000	60,000	60,000
Other Costs						
Harvesting Costs	-	4,500	9,000	13,500	13,500	13,500
Transportation	-	22,500	45,000	67,500	67,500	67,500
Working Capital	114,000	64,500	91,500	141,000	141,000	141,000
Contingency Costs (5%)	5,700	3,225	4,575	7,050	7,050	7,050
Interest on Working Capital (12%)	13,680	7,740	10,980	16,920	16,920	16,920
Total Variable Costs	133,380	75,465	107,055	164,970	164,970	164,970
Total Variable Costs for Pro-ject Period	-	-	-	-	-	810,810
Expected Annual Pre-Tax Returns	-	(133,380)	59,535	252,945	375,030	442,530
Total Returns for Project Period	-	-	-	-	-	1,506,690
Average Annual Pre-Tax Returns	-	-	-	-	-	251,115

Explanation of Key Terms and Assumptions:

Spacing: Banana plants are spaced 3 meters by 3 meters, which results in a total of 450 plants per acre.

Farm Gate Price per Bunch: Prices for bananas increase gradually as the plants mature, reflecting the market's demand for higher-quality, mature bunches.

Yield: The yield is expected to increase year-on-year as the banana plants reach their full production capacity, with a steady yield of 1,350 bunches per year starting from the third year.

Establishment Costs: These include the initial investment for land preparation, planting suckers, fertilizers, labor, and other related costs.

Maintenance Costs: These include regular activities like weeding, top dressing, and maintaining plant supports.

Other Costs: These include harvesting costs, transportation, and working capital requirements, along with contingencies and interest on capital.

Returns: Pre-tax returns are calculated as the gross income minus the total variable costs for each year. The table provides a breakdown of **total expected returns** over the entire project period of six years.

This financial summary provides a detailed overview of banana production costs and expected returns, helping farmers and investors plan effectively for optimal production and financial success

7.14 Cost Benefit Analysis for Banana Flour Processing

This analysis evaluates the cost of producing 1 kg of banana flour, considering raw material, overheads, labor, and packaging costs. A 30% profit margin is added to determine the expected sale price.

Item	No. of Units to Produce 1 kg Flour	Cost per Unit (Ksh)	Cost per kg of Flour (Ksh)
Raw Material (Bananas)	10	15	150
Other Overheads (water, electricity, depreciation, etc.)	30% of the cost of raw material	0.3	45
Labor Costs	0.3	150	45
Packaging	1	5	5
Total Production Cost per kg Flour			250
Add 30% Margin			75
Expected Sale Price			325

Explanation:

- **Raw Material (Bananas)**: The production of 1 kg of banana flour requires approximately 10 bananas, each costing Ksh 15, totalling Ksh 150.
- **Overheads**: These include water, electricity, depreciation, and other indirect costs, calculated as

30% of the cost of raw material, amounting to Ksh 45.

- **Labor Costs**: Labor costs for processing the flour are Ksh 45 per kg of flour produced.
- **Packaging**: Packaging cost per kg of banana flour is Ksh 5.
- **Total Production Cost**: The total cost to produce 1 kg of banana flour is Ksh 250.
- **Profit Margin**: A 30% margin is added to the production cost, increasing the sale price by Ksh 75.
- **Expected Sale Price**: The final sale price for 1 kg of banana flour is expected to be Ksh 325

CHAPTER 8: GENDER EQUALITY, HUMAN RIGHTS AND SOCIAL INCLUSION

8.1 Background

Studies conducted during implementation of the various value chains identified gender and human rights related challenges to participation. Women reported that cultural issues affected their rights to own land preventing their involvement in value chain activities as they could not make decisions on what to plant since all agricultural activities are dependent on land as a factor of production.

Gender roles ,triple roles for women -Reproductive. Productive and community management for women while Men's role is productive, and community politics were also sited as a hindrance to women's involvement in value chains .

Cultural practices like wife cleansing and inheritance, especially in some counties, denied widows an opportunity to participate in the value chain activities. Decision making at the household level relating to value chain selection were mostly done by men, though in some instances, women also participated in the process. But where men had migrated to towns, women were the sole decision makers on selection of value chain(s). in some counties, men dominated in decision making concerning value addition, grading, marketing, savings, access to agricultural and marketing information, as well as access to credit and training. Women and youth could not initiate any agriculture-based Income Generating Activities (IGAs) without permission from the husbands/fathers or the elderly men in the family due to cultural beliefs and patriarchy.

High illiteracy levels and low skills especially among women left them vulnerable in terms of technical matters in the value chain activities. Several farmer groups believed both English and Kiswahili languages be adopted during training, Trainers were said to use a lot of English when training and it confused the farmers making language and methodologies used a barrier.

Lack of markets: Exploitation by intermediaries affected the prices of most of the value chain produce. It was suggested that market linkages with potential external buyers be established and strengthened.

Gender and extension services - Extension services were provided to the farmers through group training and through telephone calls by private extension officers and county government extension officers. The youth indicated that the extension training courses were done early during the day when they had reported for other activities such as attending other fishponds, harvesting excluding them from the services. Women also complained that the time at which the extension trainings are done did not favour them as they are attending to domestic chores or farm activities denying them the opportunity to gain experience.

Youth attributed their inadequate participation in value chain production activities to lack of land ownership since the parents (fathers) were not willing to give them land on a permanent basis. As a result, there was serious conflict between the young men and their fathers in counties in some counties. The fathers felt that the sons (youth) were irresponsible people who would sell the land upon being given, and the money spent on drinking alcohol. This would render the entire family landless.

Widowhood – Women in all the sampled counties were targeted because of their status as widows, and the fight for family land and other capital assets always starts immediately after the husband died. Being a widow left them vulnerable to other families or even community members who want

their land and other assets. In some cases, family members secretly alter particulars of ownership documents such as title deeds to the disadvantage of widowed women.

People with disabilities often experience discrimination in their everyday life. Discrimination describes a situation where an individual is disadvantaged in some way because of a 'protected characteristic.' Discrimination takes place in different forms. It can be direct or indirect, manifest in the form of harassment, or there can be direct instructions to discriminate. Direct discrimination is based on negative attitudes, prejudice, and/or on discriminatory legislation. Indirect discrimination, for example, can be caused by physical barriers, such as stairs as the only means to get to vital locations, or using media. For example, people who are visually impaired or have difficulties hearing cannot use media without assistance.

Most of the respondents requested special training on gender mainstreaming and gender-based violence and human rights, hence this manual. The findings came from the report below and gender analysis of selected value chains conducted by the Gender Youth and Social Inclusion Advisor, MESPT in August 2024 (G.V. Masinde and C.K. Wambu, PhD November, 2021Final draft report *A Gender Equality and Human Rights Approach for The Green Employment in Agriculture Programme (GEAP), MESPT)*

8.1.1 Definition and key concepts

Sex: It identifies the biological differences between men and women. Kenya recognized and counted intersex persons during the census in 2019.

Intersex: Intersexuality is an overarching term that refers to human bodies that fall outside the strict male and female binary. The term refers to the many variations—often present at birth—that can affect a person's reproductive or sexual anatomy, which may involve genitalia, hormones, reproductive organs, and chromosomes.

For example, these variations might include being born with "female" anatomy on the outside, such as a vaginal opening, but having "male" sexual organs on the inside.- Intersex: What It Means, How It's Identified accessed on 14/11/2024

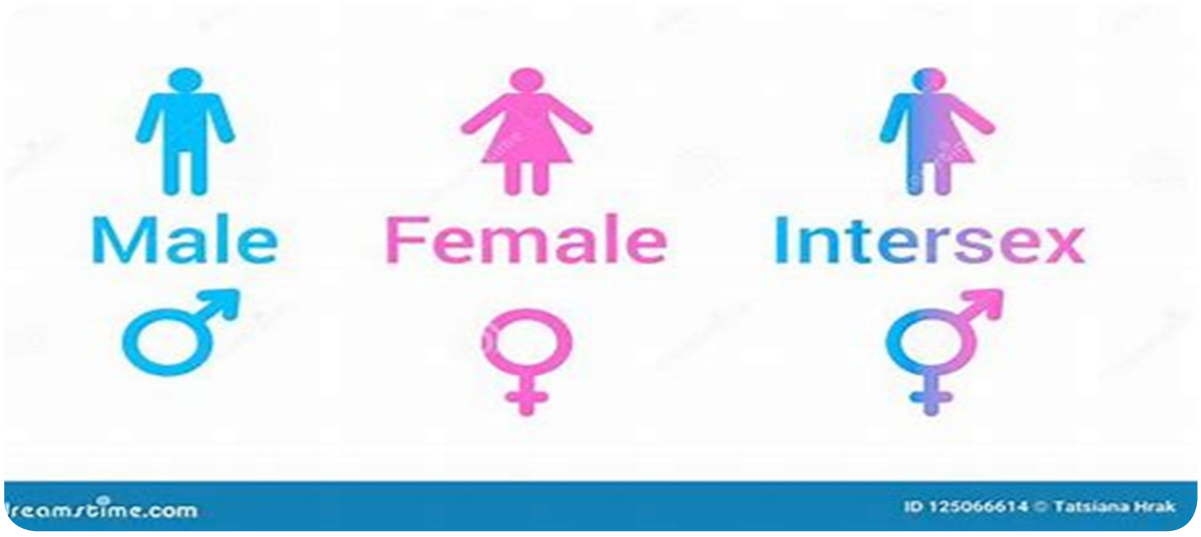


Figure 1:Kenya recognizes three genders Two genders? No, we should recognize the three in Kenya | Nation accessed on 14/11/2024.

Gender : Refers to the socio-cultural differences and relations between men and women that are learned, changeable over time, and have wide variations both within and between societies and cultures. The concept of gender also includes expectations held about the characteristics, attitudes and behavior of women and men (femininity and masculinity).

Gender equality: This is a human right that is enshrined in several declarations and conventions, including the legally binding Convention on the Elimination of All Forms of Discrimination against Women (CEDAW).

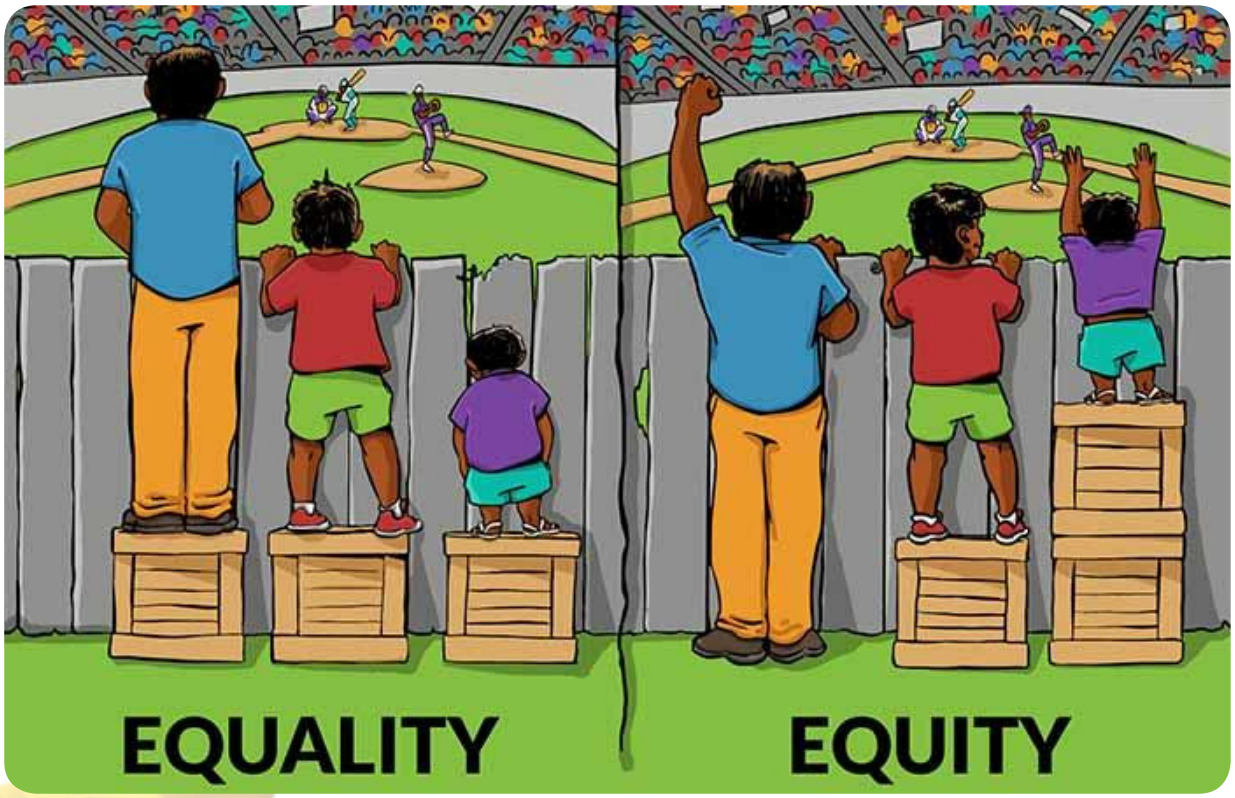


Figure 2 Equality and Equity illustrated All You Need To Know About Gender Equity Accessed on 14/11/2024

Equality does not mean that women and men are the same but that women's and men's rights, responsibilities and opportunities should not depend on whether they are born male or female. Gender equality implies that the interests, needs and priorities of both women and men are taken into consideration, recognizing the diversity of diverse groups of women and men(UN General Assembly, 1979). The centrality of **gender equality** to development is its establishment as a goal (goal 5) of the Sustainable Development Goals (SDGs) and included as a target in other SDGs.

Gender Equity: This is about fairness and being sensitive to the peculiarities of individuals, socio-economic groups, or communities. It is about equality of outcome or result of an intervention. Gender equity involves considering the different social, cultural, and economic situations of women, men, girls, and boys right from the design of an intervention through implementation to monitoring and evaluation.

Gender sensitivity: The ability to recognize the differences in terms of roles, contributions, needs and experiences of both women and men, and create a conducive environment for effective application of their specific knowledge, skills, and experiences in meeting their prioritized needs.

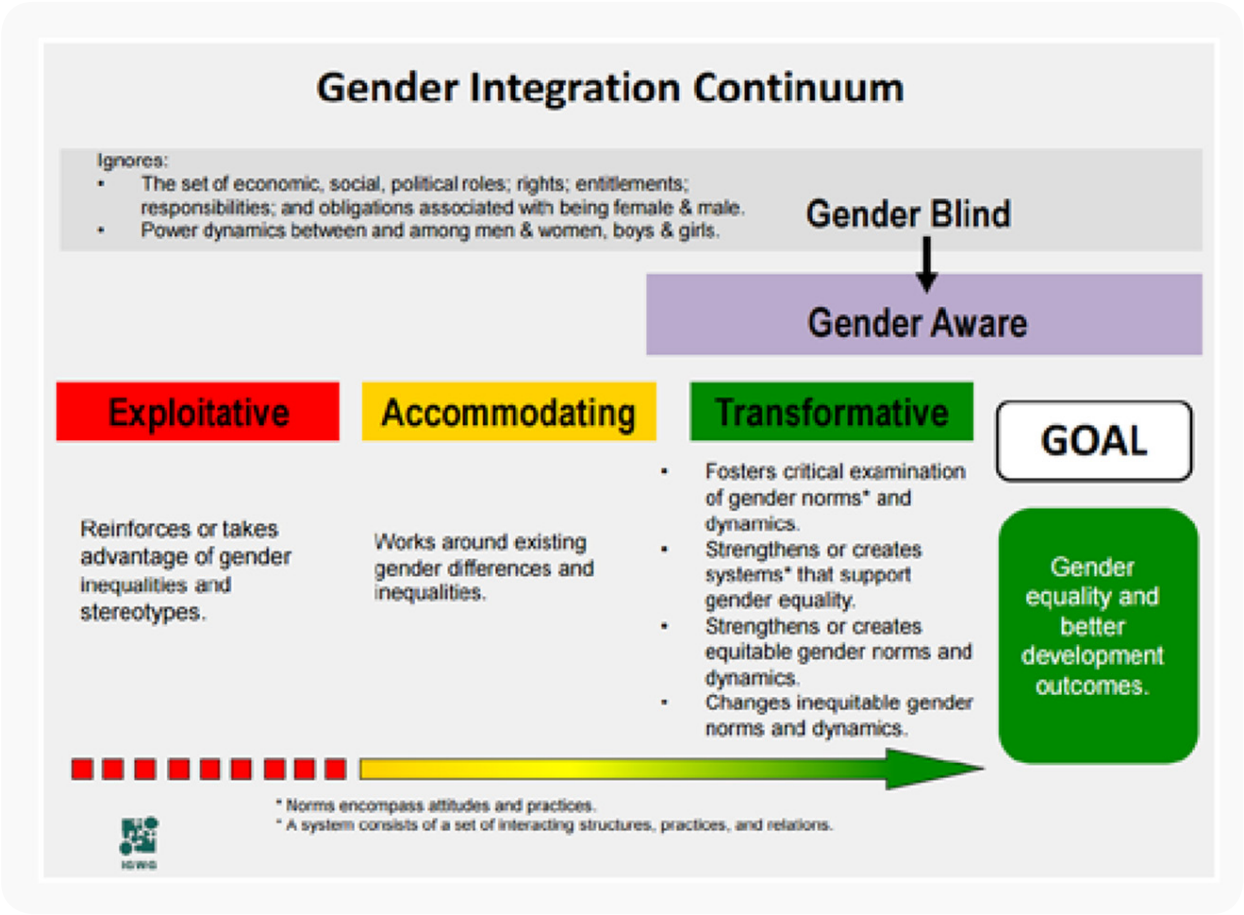


Figure 3: Gender Integration Continuum About IGWG | IGWG *accessed on 14/11/2024*

Gender aware: Recognizing or being aware of the existence of gender and gender differences in society; recognizing that men and women are positioned differently; that they have different experiences, different needs and interests, different strengths, and skills, and that these need to be considered while planning for any intervention.

Gender responsiveness: This describes the policies, programmes and projects that focus on transforming existing gender disparities to create a more balanced relationship between women and men in terms of power and decision-making as well as access to and control over productive resources. Gender responsiveness is key in meeting strategic gender needs(strategic gender needs are the needs women identify because of their subordinate position in society. These needs are long-term and relate to the empowerment of women. Strategic gender needs for women might include land rights, more decision-making power, equal pay, and greater access to credit. Addressing these needs allows people to have control over their lives beyond socially defined restrictive roles)

Practical gender needs are defined as: Needs that respond to immediate necessities such as adequate living conditions, water provision, health care, and employment. Gender-specific needs that do not challenge gender roles, such as access to healthcare, water availability, and employment opportunities.

Gender transformative

Addressing gender imbalances, changing gendered power relations, and actively building equitable social norms and structures. An organization is aware that women and men do not have equal opportunities in the household, at community level or at work. They may, for example, create equal working conditions for women and men, recognizing that special means may be required to increase the number of women in management positions or to achieve an environment free from gender-based violence (GBV). Gender transformative approaches are characterized by explicitly centering

gender norms and are thus common for interventions that have the primary goal of addressing gender issues and transforming gender relations to promote equality.

Transformative Gender Programming includes policies and programs that seek to transform gender relations to promote equality and achieve program objectives. This approach attempts to promote gender equality by:

1. fostering critical examination of inequalities and gender roles, norms, and dynamics,
2. recognizing and strengthening positive norms that support equality and an enabling environment,
3. promoting the relative position of women, girls, and marginalized groups, and transforming the underlying social structures, policies and broadly held social norms that perpetuate gender inequalities.
4. Most importantly, program/policy planners and managers should follow two gender integration principles:
    - First, under no circumstances should programs/policies adopt an exploitative approach since one of the fundamental principles of development is to "do no harm."
    - Second, the overall objective of gender integration is to move toward gender transformative programs/policies, thus gradually challenging existing gender inequities and promoting positive changes in gender roles, norms, and power dynamics.

Empowerment: Is about improving women's and men's status to enhance their decision making-capacity at all levels. It refers to the process in which women and men reflect upon their reality and question the reasons for their situation in society. It includes developing alternative options and taking opportunities to address existing inequalities. It enables them to live their lives to the fullest of their capabilities and their own choices in respect of their rights as human beings.

Gender Mainstreaming: Gender equality can be achieved by a strategy of mainstreaming which is defined by the United Nations, as '…the process of assessing the implications for women and men of any planned action, including legislation, policies, or programmes, in all areas and at all levels. It is a strategy for making women's as well as men's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programmes in all political, economic, and societal spheres so that women and men benefit equally, and inequality is not perpetuated. The goal is to achieve gender equality.'

Gender mainstreaming aims to ensure that women and men, particularly those who are disadvantaged, equally participate in and benefit from the activities of a given organization, and that all implemented projects and programmes consider women's and men's concerns and experiences as an integral dimension of their cycles. This intervention ensures that existing democratic relations are protected, at the same time preventing the further perpetuation of inequalities and the creation of new ones.

8.1.2 The Business case for gender mainstreaming

Gender mainstreaming in Agri-enterprises is not only a matter of social equity but also makes strong business sense. Here are some key points that highlight the business case for gender mainstreaming in this sector:

Increased Productivity: Women make up a sizable portion of the agricultural workforce. By providing them with equal access to resources such as land, credit, and training, productivity can be significantly increased. Studies have shown that closing the gender gap in agriculture could increase yields on women's farms by 20-30%

Enhanced Innovation: Diverse teams bring varied perspectives, leading to more innovative solutions. Women often bring unique insights into agricultural practices and market needs, which can drive innovation and improve business outcomes.

Market Expansion: Women are key players in local markets and value chains. By empowering women, Agri-enterprises can tap into new markets and consumer bases, enhancing their market reach and profitability.

Improved Financial Performance: Companies that invest in gender equality tend to perform better financially. Gender-diverse companies are more likely to have higher returns on equity and better financial performance overall.

Risk Mitigation: Gender mainstreaming can help mitigate risks associated with labor shortages and community relations. Empowering women can lead to more stable and resilient communities, which in turn supports sustainable business operations.

Compliance and Reputation: Increasingly, investors and consumers are looking for companies that adhere to social responsibility standards. Gender mainstreaming can enhance a company's reputation and compliance with international standards, attracting more investment and customer loyalty.

By integrating gender mainstreaming into their operations, Agri-enterprises can not only contribute to social equity but also enhance their competitiveness and sustainability.

8.1.3 Steps to mainstream Gender

Gender mainstreaming in Agri-enterprises involves several strategic steps to ensure that gender considerations are integrated into all aspects of the business. Here are some specific strategies:

- **Conduct Gender Analysis**: Start with a thorough gender analysis to understand the distinct roles, needs, and challenges faced by men and women in the agricultural sector. This analysis should inform all stages of project planning and implementation.
- **Develop Gender-Responsive Policies:** Create policies that promote gender equality and address specific barriers faced by women and youth. This includes policies on equal access to resources, decision-making, and opportunities for training and development.
- **Capacity Building:** Provide training and capacity-building programs for both men and women to enhance their skills and knowledge. This can include technical training, leadership development, and financial literacy.
- **Gender-Responsive Budgeting:** Allocate budget specifically for gender mainstreaming activities. This ensures that there are sufficient resources to support gender equality initiatives.
- **Participatory Planning:** Involve both men and women in the planning and decision-making processes. This ensures that the perspectives and needs of both genders are considered and addressed.
- **Monitoring and Evaluation:** Establish gender-sensitive indicators and regularly monitor and evaluate the impact of gender mainstreaming activities. This helps in assessing progress and making necessary adjustments.
- **Promote Women's Leadership:** Encourage and support women to take on leadership roles within the enterprise. This can be achieved through mentorship programs, leadership training, and creating an enabling environment for women leaders.

- **Address Social Norms:** Work on changing discriminatory social norms and practices that hinder gender equality. This can be done through community engagement, gender transformative approaches includ

8.2 HUMAN RIGHTS

Human Rights: These are rights inherent to all human beings, independent of nationality, place of residence, sex, national or ethnic origin, race, religion, language, or any other status. All human beings are equally entitled to human rights without discrimination. These include the right to life, equality before the law, the right to work, social security, education, and the right to development. These rights are all interrelated, interdependent and indivisible(Access the comprehensive text here [30 articles on the 30 Articles of the Universal Declaration of Human Rights | OHCHR]

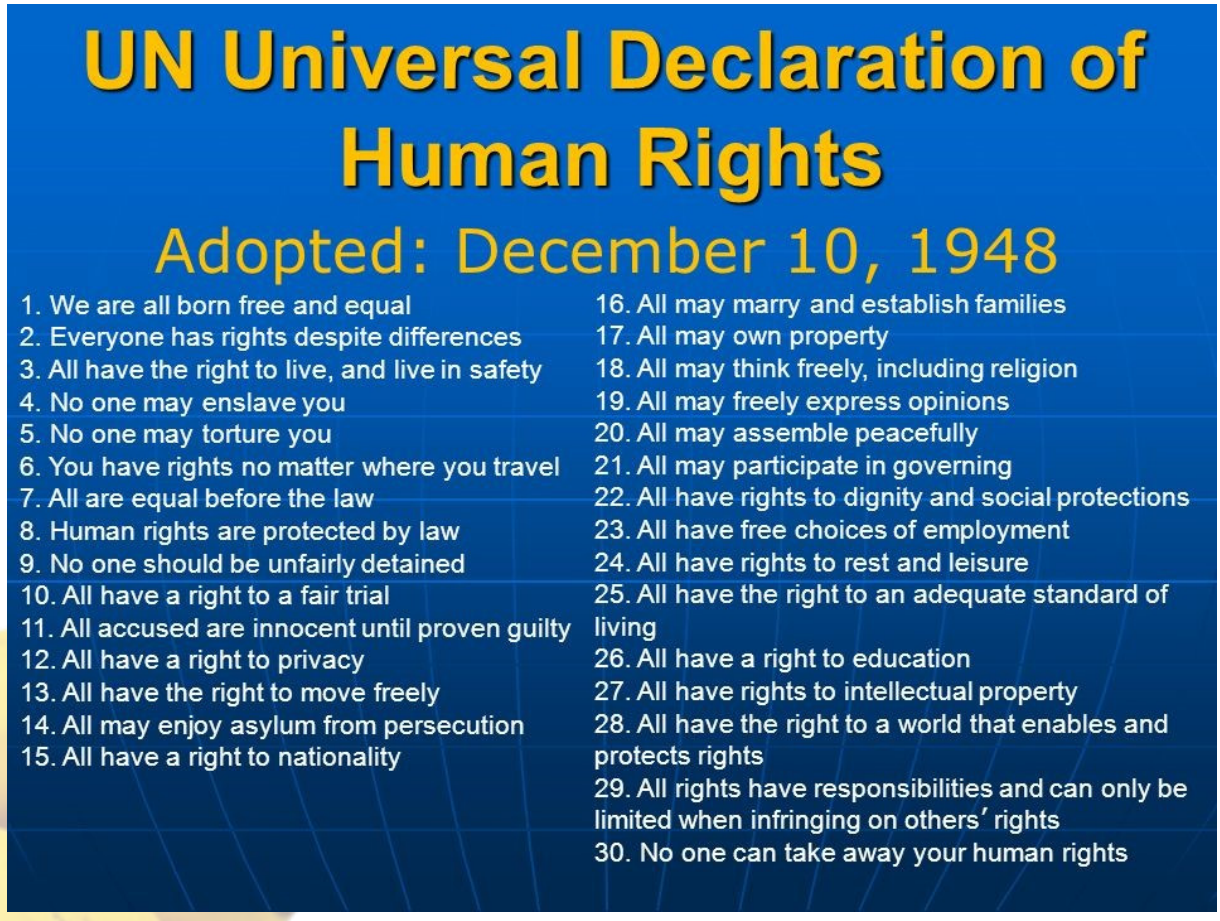


Figure 4: 30 articles of Huma rights https://rvalibrary.org/shelf-respect/law-library/national-human-rights-month/ Accessed on 14/11/2024

Children rights are also enshrined in the convention on the rights of the child(1989). Kenya enacted this into a children's act 2022.

gives equal attention to both achieving development goals and to the processes that are chosen to achieve these goals. So, within HRBA, the processes that enable the participation and inclusion of all stakeholders are important.

8.2.1 About hrba and pant principles

The HRBA builds on the norms and principles outlined in the Universal Declaration of Human Rights, and the subsequent legally binding UN treaties, which form the basis for all development cooperation. Application of the HRBA contributes to effective development cooperation processes and sustainable development outcomes. It challenges unequal power relations and social exclusion that deny people their human rights and often keep them in poverty and oppression. Microenterprise support Programme Trust (MESPT) is committed to the HRBA in all interventions.

HRBA places people living in poverty and oppression (rights holders) at the center. It is about:

- Empowering rights-holders to enable them to take action to address their situation and to claim their rights individually and collectively.
- Developing capacities and interests of duty-bearers to fulfil their obligations to respect, protect and fulfil human rights.

PANT is a tool that guides staff on the practical application of the HRBA.

It has four elements:

Participation : Do all stakeholders engage actively, in a way which allows rights-holders to contribute meaningfully and influence processes and outcomes?

Everyone has a right to freely participate in decision making that affects them and their environment. People of power have an obligation to offer meaningful participation and consultations to people affected. Everyone has the right to organize and hold opinions without any interference, and to seek, receive and impart information and ideas through any media regardless of frontiers. Promoting participation is essential for the outcome of projects and programmes. It is stated in international treaties that women, men, girls, and boys have a right to participate in decision-making that affects them. Social and cultural roles that are prescribed women and men have impact on their possibilities of choices, economic independence, access to natural resources, access to land tenure, access to clean and safe water, and decisiveness on housing, education, and livelihood.

Guiding questions are:

- Are fair and effective platforms for public-private dialogue in place, and do they give space to representatives of women and men with less power and status?
- Are measures taken to include and enhance the capacity of those with less knowledge and power so that they can participate meaningfully in the consultative processes? For example, do all stakeholders have sufficient and accessible information on the issues being addressed? Are they invited to truly participatory processes? Are barriers removed, e.g., no expensive travelling, not during busy seasons, not inaccessible for women or persons with disabilities?
- Are stakeholders actively engaged at all stages of the programming process?
- Do initiatives make space for vulnerable people to take actions of their own choosing to manage perceived risks? This is especially important in 'transformative' efforts that encourage profound changes in livelihood systems in response to climate change or market upheavals.

- The state has an obligation to respect, fulfil and protect the rights of its population. It entails a functional regulatory system for climate and environmental issues, labour law, land systems ; concrete plans for disaster risk reduction and response; rule of law including a justice system providing legal aid to poor and marginalized people and their organisations; and functional and accessible complaints mechanisms. Emphasizing the accountability of all actors (both state and non-state), whose actions impact the environment and natural resources, is a central element of HRBA. Asserting human rights without supporting effective and precise frameworks to hold duty bearers accountable is of little practical use. Strengthening the governance of natural resource management and securing natural resources tenure while also taking rights of local people, women and men, ethnic minorities, nomadic or other marginalized groups into account, can
- minimize corruption.
- have positive effects on conflict management.
- be a key step towards alleviating tensions in society and consolidating peace in post-conflict societies.
- **Guiding questions are:**
- Are the duty bearers and other actors with power identified?
- Does the initiative contribute to ensuring that public and private sector actors have systems in place to monitor and disclose social and environmental impacts according to national and international standards?
- Do monitoring and evaluation arrangements involve civil society organisations representing the concerned population?
- Are there consequences (legal, financial, or moral) for non-compliance with human rights objectives and principles?
- Has the contribution established accessible and effective mechanisms for redress and complaints?
- Does the contribution facilitate access to networks, organisations and other sources of information that may assist duty bearers to enhance their accountability and rights holders to claim their rights?

Non-discrimination : Are rights holders and the root causes of their lack of human rights identified and considered, particularly those most subjected to discrimination, marginalization, and vulnerability?

All women, men, girls, and boys are, without any discrimination, entitled to equal access to ecosystem services , market systems and natural resources as well as resilience for a standard of living adequate for their health and well-being. Discrimination may be expressed in law (explicit discrimination) and hence be part of official policy such as lack of land rights; or it may be found in practice and behavior (implicit discrimination)such as where a remote group cannot access water services because drinking wells provided by the state are too far away.

Key questions are:

- Are vulnerable groups specifically identified and targeted?
- Is there a proper analysis of the consequences of the contribution for these women, men, girls, and boys?
- Is there a plan for their inclusion and benefit including disaggregated data and indicators?

Transparency :What measures are put in place to ensure that all stakeholders can access relevant information and knowledge regarding the contribution?

Transparency All people have the right to obtain information in an accessible and timely manner, e.g., about pollution levels, water quality, environmental health risks, exploitation plans, land use plans and disaster preparedness plans. Granting sufficient and accessible information to affected women and men in planning and policy making processes is of key importance to their ability to influence and monitor developments. It is also important to consider local traditions, survival strategies and indigenous people's dependence on natural resources, and ensuring that separate views are documented. It is also essential to consider access to natural resources for people living in poverty and that a long-term sustainable development can be promoted, to avoid future opposition and conflicts.

Guiding questions are:

- Are the plans and goals of the contribution made public and explicit in an accessible manner to all stakeholders concerned, including the most marginalized groups so that they understand benefits and risks?
- Will affected women, men, girls, and boys receive sufficient, timely and accessible information, including separate views on the plans, and will they be able to take meaningful part in and influence the process?
- Will access to information regarding the local risk situation be improved and will early warning systems be developed so that the ability of vulnerable groups to protect themselves and quickly recover after disasters is strengthened?
- Does the initiative contribute to capacities and commitments for greater transparency in policies and practice affecting land and natural resource tenure, particularly in new forms of land acquisitions and concessions?

8.3 SOCIAL INCLUSION

Social inclusion is the process of improving the terms on which individuals and groups take part in society—improving the ability, opportunity, and dignity of those disadvantaged based on their identity.

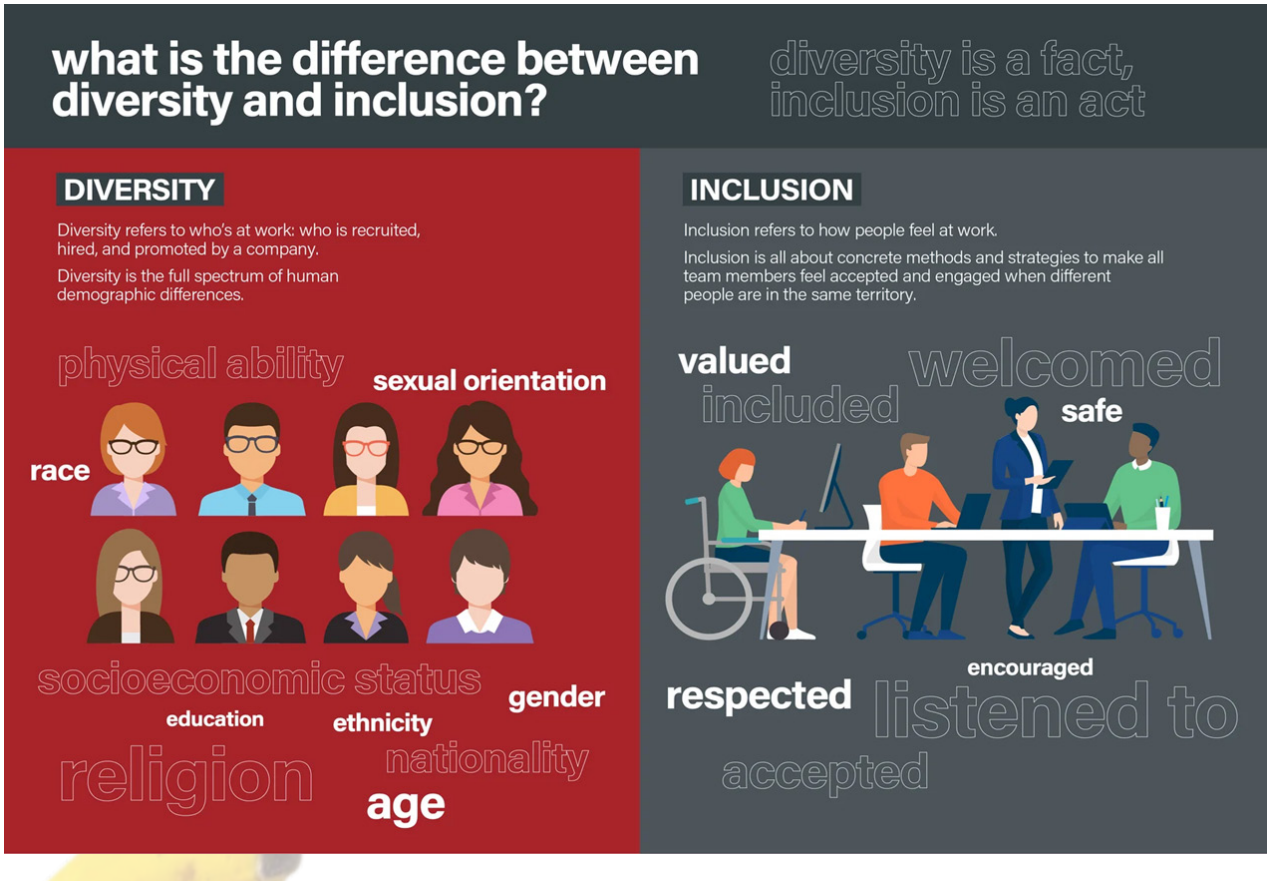


Figure 5 Diversity vs Inclusion DRP Group. (n.d.). What is the difference between diversity and inclusion? DRP Group. Retrieved November 14, 2024, from https://www.drpgroup.com/en/blog/what-is-the-difference-between-diversity-and-inclusion.

In every country, some groups confront barriers that prevent them from fully participating in political, economic, and social life. These groups may be excluded not only through legal systems, land, and labor markets, but also discriminatory or stigmatizing attitudes, beliefs, or perceptions. Disadvantages are often based on gender, age, location, occupation, race, ethnicity, religion, citizenship status, disability, and sexual orientation and gender identity (SOGI), among other factors. This kind of social exclusion robs individuals of dignity, security, and the opportunity to lead a better life. Unless the root causes of structural exclusion and discrimination are addressed, it will be challenging to support sustainable inclusive growth and rapid poverty reduction.

Social inclusion is the right thing to do, and it also makes good economic sense. Left unaddressed, the exclusion of disadvantaged groups can be costly. At the individual level, the most measured impacts include the loss of wages, lifetime earnings, poor education, and employment outcomes. Racism and discrimination also have physical and mental health costs. At the national level, the economic cost of social exclusion can be captured by foregone gross domestic product (GDP) and human capital wealth. Exclusion, or the perception of exclusion, may cause certain groups to opt out of markets, services, and spaces, with costs to both individuals and the economy.

Ensuring inclusivity means no one is left behind(leave no one behind-LNOB). The following steps make this possible.

8.3.1 Leave no one Behind

STEP 1: Who is being left behind? Gather data.

Identify who is being left behind and in what ways, and who among them is the furthest behind.

- Gather and analyze all data and information on who in the community is left behind in group activities and project interventions-sub populations and geographic localities among others with due attention to the human rights-based approach and gender considerations.
- Include and analyze data and information from a range of sources, including from national statistical offices, national human rights institutions, international human rights mechanisms, ILO supervisory bodies, civil society organizations, particularly organizations of marginalized communities as well as women's organizations, and/or community-level data, citizen science initiatives and scientific journals.
- Seek feedback and input from diverse stakeholders, including groups and populations left behind, throughout the process, from initial gathering of data to review and analysis.
- Identify data gaps.
- Complement existing data where needed, to further understand which subpopulations may be left behind, and which ones are furthest behind, using participatory approaches to gathering data.
- Combine relevant national and UN development, human rights, conflict, inequalities, political, risk and humanitarian analysis for more joined up assessment of who is left behind and why – with a view to identifying the furthest behind.
- Triangulate the data from the above sources through a consultative analytical process to develop a mutual understanding across all interventions that consider the voices and experiences of communities together with other data sources.

STEP 2: Why? Prioritization and analysis

- Frame as problems the LNOB assessment's main findings are about the ways in which people are left behind. Identify the relevant human rights and international labour standards.
- Conduct a root cause analysis to identify why people are being left behind and to enable responses to the root and underlying causes of inequalities, including gender inequalities, vulnerability, deprivation, discrimination, displacement, and exclusion.
- Conduct a role pattern analysis.
- Conduct a capacity gap analysis.
- Questions to be asked at each step: Causal analysis WHY? Which rights are implicated that explain why there is a problem? Role pattern analysis WHO? Who is the duty-bearers? Who are the rights holders? Who must do something about it? Capacity gap analysis WHAT? What capacity gaps are preventing duty-bearers from fulfilling their duties? What capacity gaps are preventing rights holders from claiming their rights? What do they (each) need to act?

STEP 3: What? What should be done?

Identifying what should be done and by whom.

- Identify actions and interventions to address challenges, barriers, and capacity gaps. Areas include

advocacy, enabling the environment, capacity development ,community empowerment, quality and accessibility of services, partnerships including civil society.

- Prioritize, considering the commitment to address the furthest behind first.

STEP 4: How? How to measure and monitor progress

- Help identify and contextualize LNOB indicators and targets – having a clear overview of data and data gaps and a plan for monitoring progress is an important precondition for effective follow-up and review.
- Quantitative and qualitative indicators will be necessary – measuring commitments, processes, and outcomes.
- Support innovative ways of tracking, visualizing, and sharing information.
- Develop the stakeholder capacity to monitor inequalities, including gender inequality and discrimination, including that of governments (national, subnational) and communities.

STEP 5: Advancing accountability for LNOB.

- Ensure accountability for LNOB within the in the organization and the interventions.
- Support the integration of LNOB in interventions follow-up and review processes, including in narrative reports.
- Support national accountability to people left behind.

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ANNEX I

MESPT
MICRO ENTERPRISES SUPPORT PROGRAMME TRUST

AQUACULTURE VALUE CHAIN TRAINING WORKSHOP FOR XXXX

TRAINING VENUE: XXX **DATES: XXX**

SAMPLE PROGRAMME

Date and Time	Activity	Duration	Responsible

ANNEX 11.: List of participants who validated this value chain manual

S/NO	NAME	INSTITUTION
1	Joseph Kairu	County Government of Siaya
2	Winston Motanya	County Government of KISII
3	Nicholas Manyinsa	County Government of KISII
4	Cecilia Mutuku	County Government of MACHAKOS
5	Paul Busienei	County Government of NAKURU
6	David Kimera	Youth Agri-Preneur
7	Lawrence Swanya	County Government of MACHAKOS
8	Kenneth Kagai	County Government of TRANS-Nzoia
9	Benedict Khanyifu	County Government of TRANS-Nzoia
10	Mwalimu Menza	Kenya Agricultural and Livestock Research Organization
11	George Kamami	County Government of MAKUENI
12	Moses Munialo	County Government of BUGOMA
13	Agesa Eric	County Government of KAKAMEGA
14	Benard Mainga	County Government of KWALE
15	Jane M Kamamu	County Government of KILIFI
16	Teresia Ndungu	County Government of NYANDARUA
17	Wilbur Mutai	County Government of UASIN-GISHU
18	Stephen Odipo	Kenya Agricultural and Livestock Research Organization
19	Solomon Mbivya	PAPA FARMERS Limited
20	William Mwangi	County Government of MAKUENI
21	Doreen Kinoti	Micro-Enterprises Support Programme Trust
22	Serah Nzau	Micro-Enterprises Support Programme Trust
23	Margaret Kikuvi	Micro-Enterprises Support Programme Trust

KALRO
Kenya Agricultural & Livestock Research Organization

MESPT
MICRO ENTERPRISES SUPPORT PROGRAMME TRUST

MINISTRY OF FOREIGN AFFAIRS OF DENMARK
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